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CLASSIC MINERAL COLLECTING LOCALITIES IN ONTARIO AND QUEBEC

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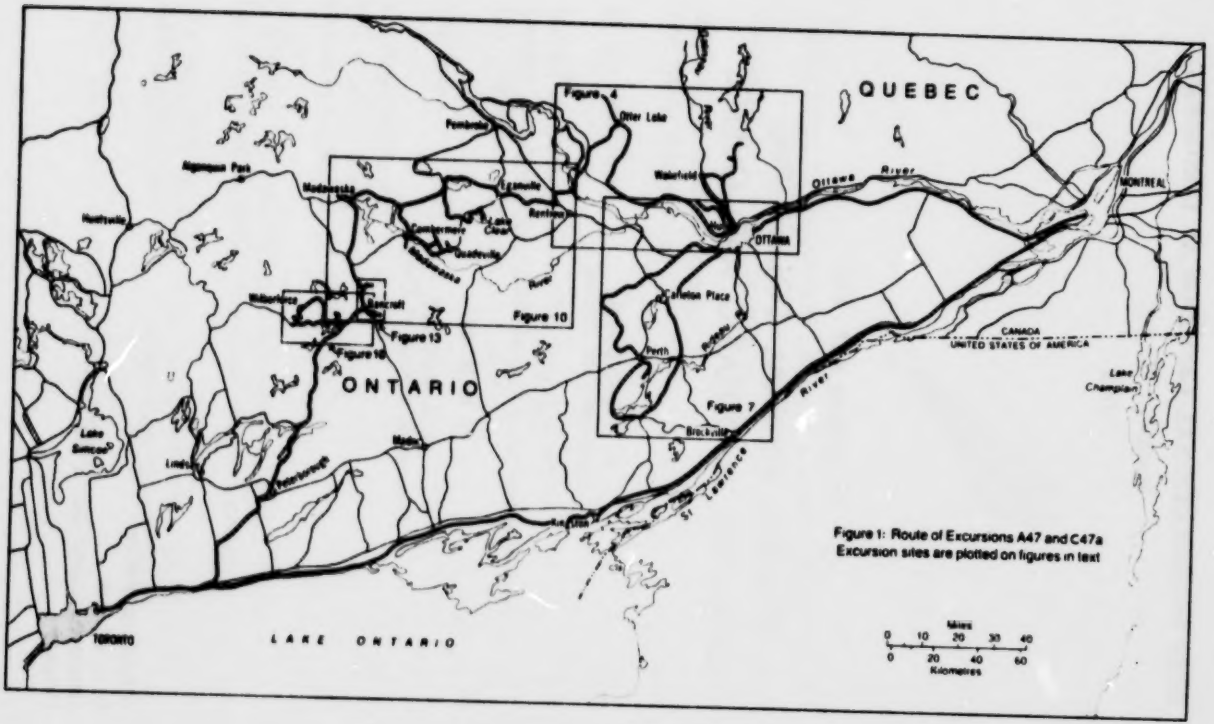

Figure 1: Route of Excursions A47 and C47a
Excursion sites are plotted on figures in text

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INTRODUCTION

The parts of Ontario and Quebec covered by this excursion have, for more than a century, yielded fine specimens of a large variety of minerals which are represented in many collections throughout the world. As will be evident from the sections on geology, the area is a particularly favourable geological host for interesting minerals; known mineral occurrences of significance to the collector now number in the hundreds, and new localities are being discovered each year. For this excursion the authors have selected 34 localities which have become classic either as prime examples of several types of deposits, or as localities for rare and outstanding mineral specimens.

The first part of the guidebook provides an introduction to the geology of the area, supplemented by discussion of the major types of occurrences; the second part provides descriptions of the mineral localities to be visited. Contributions by the authors are as follows: E. R. Rose prepared the introductory sections on geology and pegmatites and descriptions of the mineral localities in the Perth area; D. D. Hogarth prepared the section on calc-silicate rocks and descriptions of the localities in the Gatineau River and Otter Lake - Ottawa River areas; L. Moyd prepared the sections on vein-dykes and the nepheline-corundum belt of southeastern Ontario (with collaboration of E. C. Appleyard on petrology of the latter), and descriptions of the related localities in the Madawaska Valley, Bancroft and Wilberforce areas; and H. R. Steacy prepared descriptions of the granitic pegmatite localities in the Madawaska Valley and Bancroft areas, compiled the generalized geological map and edited the guidebook, attempting to preserve the individual style of the authors. The figures were prepared by the Geological Cartographic Unit of the Geological Survey of Canada, whose services are gratefully acknowledged. The authors have relied throughout on many of the source-materials listed in the references.

EXCURSION ROUTE

The excursion route is shown in Figure 1. The excursion originates in Montreal and travels westward, with overnight accommodation at Ottawa (three nights), Combermere (three nights), Bancroft (three days) and Toronto (one night). Ottawa, Combermere and Bancroft are centres for field trips; in Toronto, a visit will be made to the mineral gallery of the Royal Ontario Museum. The excursion returns to, and ends, in Montreal.

PART 1

GENERAL GEOLOGY OF THE EXCURSION AREA

REGIONAL SETTING

The excursion area lies within the Precambrian Grenville Province of the Canadian Shield (Fig. 2). It is underlain to a large extent by granitic rocks and gneisses that formerly were assigned to the "Laurentian System"; and by crystalline limestone and other metasedimentary rocks lithologically similar to the "Grenville Series" first described by Sir William Logan of the Geological Survey of Canada in 1863 at the town of Grenville, Quebec, some 60 miles (96 km) east of Hull and Ottawa on the Ottawa River. The area is also underlain in part by the St. Lawrence Platform, in which a sequence of almost flat-lying sedimentary rocks of Palaeozoic age unconformably overlaps the Canadian Shield on its southern fringe, north of Lake Ontario. In the Ottawa Valley, faulted and folded segments of the Palaeozoic formations have been down-faulted into the Shield rocks along the Ottawa - Bonnechère graben (Kay, 1942), which is a part of the St. Lawrence rift system (Kumarapeli and Saull, 1966). Some of these faults are reflected by abrupt, northwesterly-trending escarpments and by broad valleys, such as that of the Ottawa River (see Figure 3). Physiographically, the area is a glaciated, dissected peneplane surface with local relief that rarely exceeds 1,000 feet (300 m). Rock exposures are abundant in most parts of the area. A generalized geological map of the excursion area is shown in Figure 3.

GRENVILLE PROVINCE

The exposed part of the Grenville Province (Wilson, 1925; Gill, 1952) forms a northeasterly-trending belt, 250 miles (400 km) wide and 1200 miles (2000 km) long, extending from Lake Huron to the Labrador coast, bounded by the "Grenville front" on the northwest, and by the St. Lawrence Platform and Appalachian Orogen on the southeast (Fig. 2). The Grenville Province consists mainly of contorted metamorphic and igneous rocks. In eastern Ontario the Grenville Province includes at least three complex groups of metavolcanic (Keewatin type) and metasedimentary (Grenville type, Hastings type) rocks, and a great variety of igneous intrusions and hybrid rocks, as shown in the Table of Geological Formations, Table 1 (after Rose, 1958).

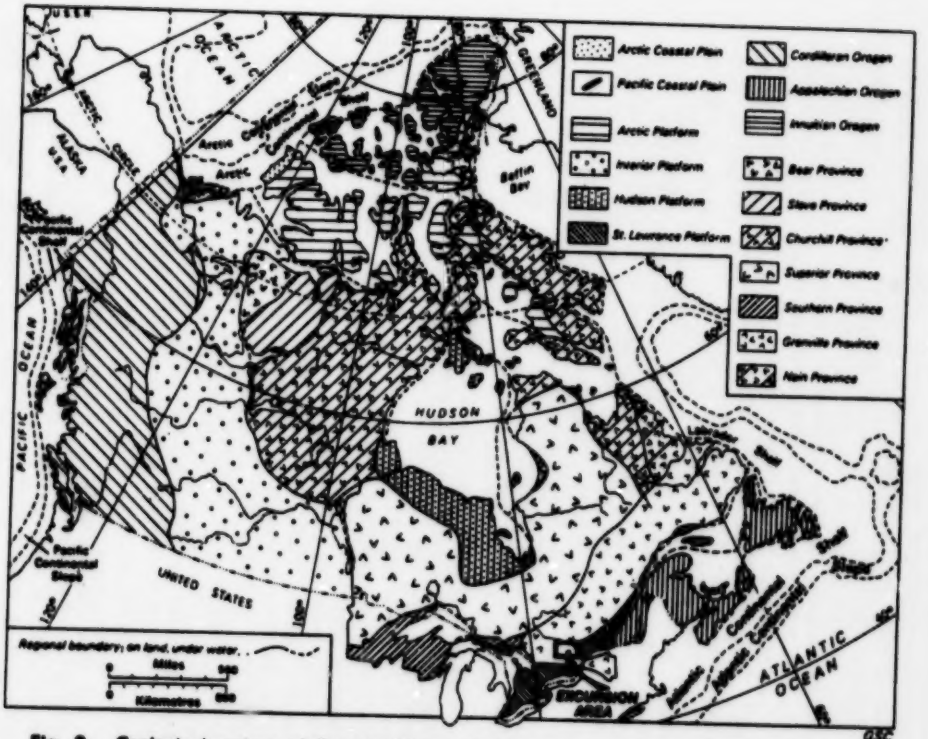

Fig. 2. Geological regions of Canada [(from Geology and Economic Minerals of Canada; Geol. Surv. Can., Econ. Geol. Rept. 1 (1970)].

In this table an attempt has been made to link historic usage and terminology with current nomenclature. The rocks comprise orthogneiss, paragneiss, schist, granulite, metamorphic pyroxenite, skarn, crystalline limestone, dolomite and magnesite, quartzite, iron formation, slate, hornfels, amphibolite, brecca, conglomerate, large masses of granite, syenite, nepheline syenite, diorite, anorthosite, and gabbro, and smaller bodies of peridotite, pyroxenite, basalt, lamprophyre, rhyolite, felsite, aplite, pegmatite, diabase and trap (dolerite). In western Quebec the Precambrian rocks are overlain unconformably by Lower Cambrian latite (Buckingham area) and intruded by Middle Ordovician dolerite dykes (Wakefield and Buckingham areas). The geological succession and geochronological dating in the area north of Ottawa is shown in Table 2 (after Hogarth). A number of minor intrusions with alkalic and carbonatite affinities have recently been recognized in the Ottawa area and have shown a range in age from 190 m.y. to 920 m.y. by the K/Ar dating method. An additional complexity thus enters the geological history of the area because of uncertainties concerning carbonatites (see Guidebook for Excursions B-23 to B-27, XXIV International Geological Congress).

Extensive belts of banded crystalline carbonate rocks, and large anorthositic intrusions, are outstanding components of many parts of the Grenville Province. The former, consisting largely of crystalline limestone and dolomite, and calc-silicate rocks, contain magnesite, brucite, apatite, mica and lead-zinc deposits; and the latter commonly carry titaniferous magnetite and ilmenite occurrences. Also, generally in the crystalline carbonate belts, and particularly in the Bancroft district, areas of nepheline syenite and nepheline and corundum gneisses are of economic as well as scientific interest (Adams and Barlow, 1910). Uranium-thorium and rare-earth bearing pegmatites of the Grenville Province are also notable in the Bancroft area of Ontario (Ellsworth, 1932; Satterly, 1957), and the Otter Lake area of Quebec (Shaw, 1958).

All but the youngest of these Precambrian rocks were involved in the Grenville orogeny (Hewitt, 1956), which has an average K/Ar age of about 950 m.y. (Stockwell, 1964) and during which large bodies of granitic and syenitic rock and pegmatite were formed (Wynne-Edwards, 1964). The Grenvillian orogeny was probably superimposed on older orogenic belts of metavolcanic, metasedimentary, and intrusive rocks of possible Archean or early Proterozoic age

Table 1

Table of Geological Formations, Excursion Area (Ontario portion)
(After Rose, 1958)

Orogeny	Eon	Era	Period	Epoch, sub-epoch, formation or group	Description
		Cenozoic	Quaternary	Recent	Peat, marl, sand, clay
				Pleistocene	Glacial drift
			Unconformity		
	PHANEROZOIC	Paleozoic	Ordovician	Queenston	Shale
				Lorraine	Shale
				Trenton and Black River	Mainly limestone
				Chazy	Mainly limestone and shale
				Beekmantown	Mainly dolomite
			Cambrian (?) or Cambro-Ordovician	Potsdam-Nepean	Mainly sandstone, arkose and conglomerate
			Unconformity		
GRENVILLIAN	PROTEROZOIC	Helikian (?)			[1] Trap (Fine-grained gabbro, diabase).
					Pegmatite Granite-syenite-felsite(granitization)
					[2] Nepheline syenite (nephelinization)
					Trap (Fine-grained gabbro and gabbroic anorthosite)
ELSONIAN (?)				Morian 'Series'	Syenite-granite Diorite Gabbro Gabbroic anorthosite } Related (differentiated?) sequence with associated magnatite.
				Intrusive contact	
				Hastings 'Series'	Meta-sedimentary rocks including blue-gray limestone, buff-weathering dolomite, and conglomerate (carrying crystalline limestone, "Eozoon", volcanic and granitic cobbles).
			Logan's 'Laurentian System'	Unconformity	
HUDSONIAN (?)		Aphebian(?)			Granite (?) (granitization)
				Intrusive contact	
				Grenville 'Series'	Gneisses, schists, crystalline limestone, quartzite, amphibolite, conglomerate; rocks of obscure origin: Logan's 'Fundamental or Ottawa Gneiss'
	ARCHEAN(?)			Disconformity (?)	
KENORAN (?)				Keewatin 'Complex'	Chloritic schists, meta-volcanic rocks (Period of vulcanism and granitization (?) or granite intrusion (?)).

1. These trap dykes may be eqivalent in age as may some of the granites.
2. Approximate position suggested by Hewitt, (1961, p. 34)

(Table 1). During the overprint of this protracted orogeny, the rocks in much of the Grenville Province reached a high metamorphic grade and many of the primary features in them were modified or obliterated by recrystallization, metasomatism and reconstitution.

ST. LAWRENCE PLATFORM

The St. Lawrence Platform overlaps the southeastern flank of the Shield, and forms a wedge between the Appalachian Orogen to the southeast and the Grenville Province to the northwest. The platform consists of undeformed, and locally, slightly deformed sedimentary formations of Palaeozoic age that were deposited over a period of more than 250,000,000 years. During this time a transgressing Palaeozoic sea flooded the peneplaned area, and beds of arkose, conglomerate, sandstone (Potsdam-Nepean), dolomite (Beekmantown), limestone and shale (Black River-Trenton) of Cambro-Ordovician age, were deposited in a basin eroded in Precambrian rocks.

The Palaeozoic cover is thin and intermittent in the Ottawa - Perth area, but thickens easterly to more than 2,000 feet (610 m) at Montreal, where the Palaeozoic beds are intruded by the basic alkaline plugs, pipes, dykes and sills of Mount Royal, the niobium (columbium)-rich alkaline carbonatite ring complex of Oka, the diatreme breccia of Ile Ste. Hélène, and other Monteregian intrusions of Cretaceous age. South of Perth an eroded arch of uplifted Precambrian rocks, the Frontenac axis, forms the Thousand Island section of the St. Lawrence River, and separates the Kingston area from the Ottawa area of Palaeozoic rocks.

The well-washed quartzose sandstone beds near the base of the Cambro-Ordovician section provided the quality building stone from which the Federal Parliament Buildings and many others in Ottawa were built, as well as a source of high-silica sand suitable for glass making. The overlying grey, Ordovician limestone of the Ottawa area is also a good constructional material, and a source of rock for cement, building stone and road metal.

Post-Ordovician Deposits

Carbonate and quartz-carbonate veins are more abundant in the basement than in the cover rocks, and both types commonly carry calcite, fluorite, barite, celestite, quartz, specular hematite, galena, sphalerite, selenite, anthraxolite, and other minerals. In a few places, as at the abandoned

Table 2

GEOCHRONOLOGY OF THE OTTAWA REGION

Era	Period	Sedimentary Rocks	Igneous and Metamorphic Rocks	Age(m.y.)[1]	δ[2]	n[3]
Cenozoic	Neogene	Pleistocene & Recent unconsolidated sediments				
Mesozoic	Triassic					
Paleozoic	Pennsylvanian		Blackburn carbonatites	190[4]		1
			Buckingham peridotite	275		1
	Ordovician	Queenston Fm. (red shale) Russell Fm. (grey shale & dolomite) Carlsbad Fm. (grey shale) Billings Fm. (black & brown shale) Eastview Fm. (limestone) Ottawa Fm. (limestone) St. Martin Fm. (limestone) Rockcliffe Fm. (shale & sandstone) Oxford Fm. (dolomite) March Fm. (dolomite & sandstone)	Diabase dykes (Buckingham swarm)	446	41.6	5
	Cambrian or Ordovician	Nepean Fm. (sandstone)				
	Cambrian		Onslow syenite dyke Buckingham latite	575	14.7	3
Helikian			Meach Lake carbonatite	920	48.9	4
			Pinks Lake peridotite Kingsmere diorite dyke Wakefield monzonite Kingsmere amphibolite Wakefield pegmatites Buckingham lamprophyre complex Old Chelsea metapyroxenites	1008	51.4	11

1. K/Ar ages compiled from records of the Geological Survey of Canada, McGill University, Carleton University and the University of Ottawa
2. Standard deviation.
3. Number of determinations.
4. Maximum age. Possible contamination of sample with Precambrian biotite.

Kingdon mine near Galetta, about 30 miles (48 km) west of Ottawa, calcite-galena veins of this type penetrate both the Grenville-type crystalline limestone and the overlying Beekmantown dolomite and are of post-Middle Ordovician age, with the upper limits indeterminate because of erosion.

Pleistocene and Recent

The area was glaciated by the continental ice sheet during Pleistocene time and deposits of boulder clay, sand, gravel and erratics cover much of the bedrock. Following retreat of the Pleistocene ice, the Ottawa Valley was invaded by the sea, which deposited marine clay and shoreline sands and gravels. Dark muck and peat have accumulated in bogs.

MAJOR HOST ROCKS

The mineral localities of this excursion all occur in rocks of the Grenville Province, in four main environments: (1) pegmatites, (2) marble and calc-silicate rocks, (3) nepheline- and corundum-bearing gneisses, and (4) calcite veindykes. These are discussed in the following sections as an introduction to the descriptions of the individual localities.

Pegmatites

Pegmatites (mainly granite pegmatites), are widespread and common in the Grenville Province as late synorogenic phases associated with many of the granitic intrusions and late-stage granitization processes of several ages. The pegmatites occur chiefly as irregular dykes which range from a few feet to more than a mile (2 km) in length, and from a few inches to several hundred feet in width, and commonly extend several hundred feet in depth. They are commonly found in swarms, and characteristically display very coarse crystals and sharp contacts with their host rocks. Most dykes are simple granite pegmatite consisting mainly of coarse-grained quartz, microcline (microperthite), amazonite and albite-oligoclase (peristerite), with accessory hornblende, biotite, tourmaline, garnet, chlorite, pyrite, muscovite, sericite, and calcite. Some dykes are crudely zoned with a quartz or calcite core, an interior zone of microcline, plagioclase, perthite, graphic granite, quartz, tourmaline, biotite, hornblende, and muscovite, and a marginal zone of graphic granite or hybrid material. A few dykes are more complex, carrying beryl, zinnwaldite, molybdenite and other rare-element minerals such as uraninite, uranothorite, thorite, euxenite, fergusonite, samarskite, columbite-tantalite, allanite, lyndochite, betafite, ellsworthite, xenotime,

cenosite, monazite, bastnaesite, gadolinite, titanite (including variety keilhauite or yttrotitanite), zircon (cyrtolite), strüverite, chevkinite, hellandite and bismuth minerals. Pegmatitic syenite is also found in eastern Ontario associated with bodies of syenite and nepheline syenite, as in the Craigmont and Bancroft areas where corundum and nepheline have been commercially recovered from the pegmatitic masses. These are dealt with in greater detail in the section on the nepheline and corundum belt of sontheastern Ontario. Complex replacement-type uranium-bearing pegmatites occur in the Bancroft area but are not as well defined as the others. Such bodies may represent reconstituted as well as metasomatic pegmatite.

In the Perth-Ottawa-Gatineau area the granitic pegmatite dykes are of two types, namely: red dykes, characterized by abundant microcline strongly pigmented with hematite, and white dykes, rich in quartz and feldspars free of hematite. Normally these two types of dykes are separate and distinct, but in several places in the Perth area they are closely associated and transitional. In fact, potash-rich feldspars may be bleached from their characteristic salmon-red colour to pastel shades of pink, cream and buff, whereas soda-rich feldspars (normally grey to white) may be coloured pink or red as a result of a pervasive type of alteration involving oxidation of an iron component of the feldspars and ferromagnesian minerals. Many of the pegmatite dykes cutting marble in the Gatineau and Perth areas are white, and most of those cutting granitic rocks are red. In the Gatineau area some of the granite pegmatite dykes appear to be enriched in yttrium, mainly in the form of yttrian garnets, yttrian thorite, euxenite, hellandite and fergusonite, (Hogarth, pers. comm., and Miles, et al, 1971). Some of the dykes in the Perth area also carry yttrium mainly in the form of euxenite, fergusonite, and cyrtolite, as well as cerium in the form of allanite, monazite and bastnaesite.

Marble and Calc-silicate Rocks

Marble and associated calc-silicate rocks occur abundantly throughout the excursion area (Fig. 3). In their classic memoir on the Haliburton-Bancroft region, Adams and Barlow (1910, pp. 192-226), divide the marble into a 'white crystalline limestone' and a 'blue limestone'. The former is coarse grained and of common occurrence near Bancroft and Ottawa; the latter is fine grained and common about 25 miles (40 km) south of Bancroft. The blue limestone contains some quartz, a little diopside and pigmenting organic material.

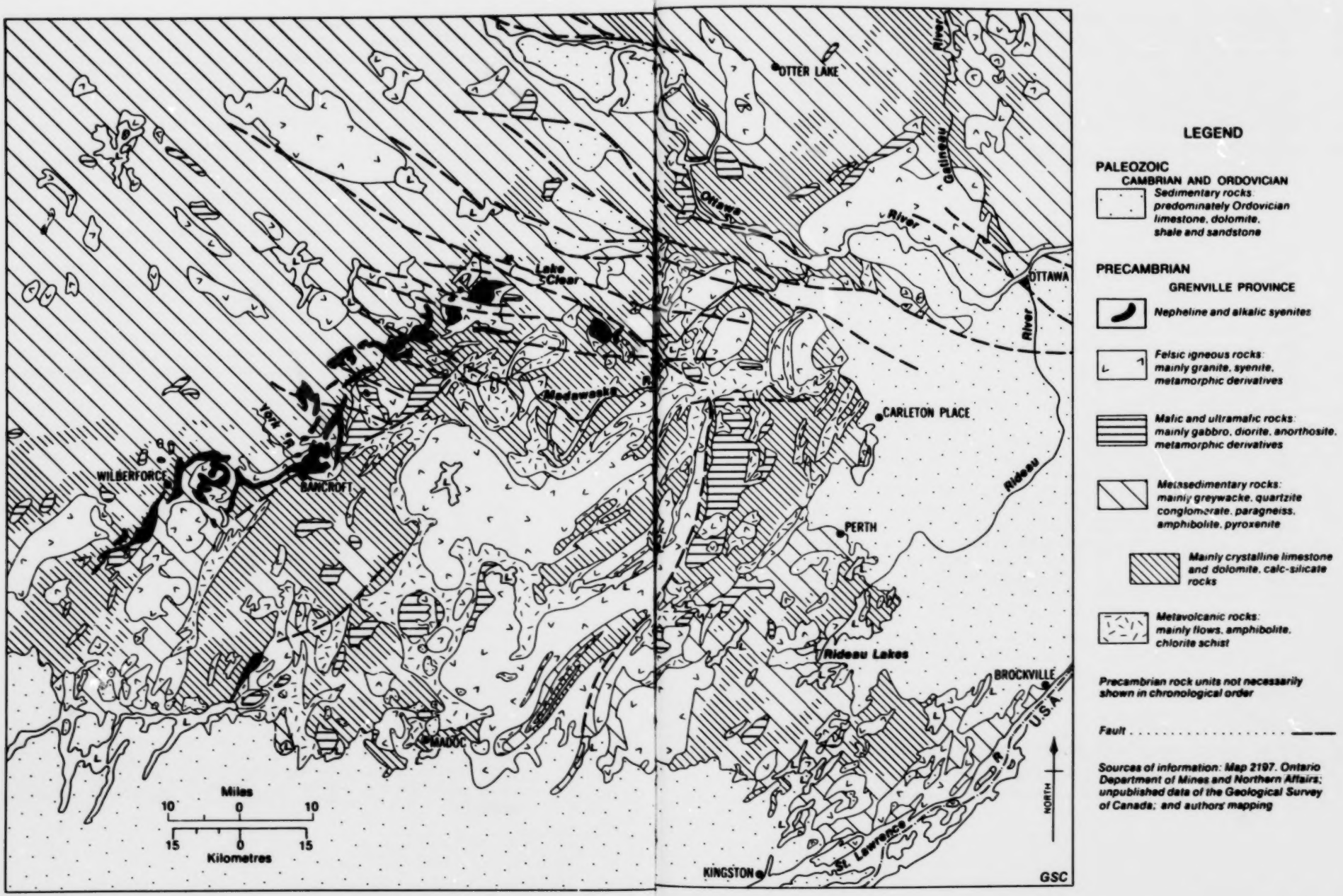

Figure 3. Generalized geological map of Excursion Area.

One of the most common types of white marble is a coarse-grained graphitic variety containing little other than calcite, graphite, quartz and phlogopite. Feldspar, when present, is white and almost invariably perthite. An excellent example of this marble will be seen in roadcuts along the southern section of the Gatineau Parkway.

Lenses of dolomite are common in both the white and blue marble. Quartzitic fractions give rise, on regional metamorphism, to such associations as:

calcite + chlorite
calcite + forsterite (normally replaced by serpentine)
calcite + phlogopite
calcite + actinolite (± phlogopite, ± diopside)
calcite + diopside (± phlogopite), and
calcite + chondrodite + spinel

In these transformations, the blue marble loses its colour and becomes white. Examples to be seen on the excursion are diopside-tremolite marble at Tory Hill and diopsidic marble in the hanging wall of the MacDonald feldspar mine.

Normally, regional metamorphism of the marble has not proceeded beyond the forsterite + calcite stage of Skippen (1971) but, on contact metamorphism, wollastonite and brucite may be developed. Thus the wollastonite + idocrase + grossularite + calcite association is found in marble at the contact with the Wakefield syenitic batholith near Ottawa, and in contact zones of marble and gabbro near Marmora and Haliburton, Ontario. The silicated zones to be seen on the east side of the York River crossing may have been formed by the intrusion of nearby gabbro or perhaps igneous nepheline rocks into marble. Forsterite - dolomite - calcite marble is developed near the contact with gabbro at Portage-du-Fort, Quebec. Brucitic marbles of the Maxwell and Cross deposits occur as roof pendants within the Wakefield syenite batholith.

Scapolite in such associations as scapolite + calcite (± graphite), scapolite + grossularite, and scapolite + diopside (± microcline) are common north of Ottawa. A scapolite - diopside rock may be seen at the Vavasour Mine.

Granoblastic calc-silicate rocks, common in the Grenville Province, are hosts for many interesting minerals. Shaw *et al.* (1963) recognized the following associations:

(1) scapolite + diopside + titanite
(2) diopside ± amphibole ± calcite ± phlogopite

(3) calcite ± diopside ± phlogopite
(4) pyroxene + plagioclase + microcline + titanite + quartz and
(5) diopside + calcite + fluorite + apatite

These calc-silicate rocks are commonly the host-rocks for phlogopite, apatite and molybdenite deposits, which are described in the section on 'vein-dykes'. Silica-poor systems give rise to pyroxene + spinel and pyroxene + forsterite + spinel associations, some of which are sparingly found in Gatineau Park, Quebec.

Most studies indicate that calc-silicate rock was formed through metamorphism of dolomitic marble. G. Noizet (1959, Doctorate thesis, Univ. Nancy), in studies of similar rocks from southeastern Madagascar, considered isochemical transformations. Shaw *et al.* (1963), in an investigation of calc-silicate rocks ('skarns') from Ontario and Quebec, concluded that they were formed by metasomatic addition of constituents to marble but that pyroxene + feldspar + titanite + quartz assemblages resulted from metasomatic alteration of granite pegmatite. Similar rocks in southeastern Madagascar were termed dissogenites and were considered to have formed through endometamorphism of granite pegmatite by the enclosing marble and calc-silicate rock (Lacroix, 1941, pp. 61-66). A gradation from silicated marble to a diopside - actinolite - calcite rock will be seen from the bus along the Gatineau Parkway, near Kingsmere, Quebec.

Some calc-silicate rocks may have a different origin. For example, the calc-silicate rock near the Evans-Lou mine is high in Ni and Cr and may represent a metamorphosed peridotite. Spence (1929, p. 40) and Vokes (1963, p. 178) note that some pyroxenites show chilled contacts with the enclosing rocks. However the melting temperature of pyroxene (1386°C for $CaMgSi_2O_6$) would appear excessive and eliminate the possibility of a pyroxenite melt.

Table 3 summarizes all the data that has been presented on the temperature-pressure conditions of formation of rocks from the Grenville Province.

Nepheline and Corundum Belt of Southeastern Ontario

The belt of nepheline- and corundum-bearing gneisses of the Haliburton-Bancroft area (Fig. 3) was first mapped and described by Adams and Barlow early in this century, and some of the occurrences were visited during the XII International Geological Congress in 1913. Minerals from this

Table 3 Geothermometry of rocks from southeastern Ontario, southwestern Quebec and northern New York State

Temp (°C)	Press (km. depth)	Rock - Type	Area	Method (Geothermometer)	Reference
700	24-25	pelitic gneiss	Gatineau Park, Quebec	Mg in co-existing biotite and garnet; aluminosilicates	L. Guilloux (1969, Ph.D. thesis, Univ. Grenoble)
430-650	10-11	granite pegmatite	Bancroft, Ontario	pyrite; decrepitation	Peach (1951)
600		calcite-dolomite-tremolite marble	Wakefield, Quebec	calcite-dolomite	Y. Hay (1970, M. Sc. thesis, Carleton Univ.)
580		calcite-dolomite forsterite marble	Gibb Lake, Pontiac County, Quebec	calcite-dolomite	Sheppard (1966, Ph.D. thesis, McMaster Univ.)
550		dolomitic marble	Gouverneur, N.Y.	calcite-dolomite; magnetite - ilmenite	Engel and Engel (1958)
500-600	15-22	dolomitic marble; pelitic rocks	Gatineau Park and Otter Lake, Quebec	calcite-dolomite; Al_2SiO_5 system	A.S. Wong (1971 M. Sc. thesis Univ. of Ottawa)
475-600		calc-silicate rock	North Burgess township, Ontario	pyrite	Currie (1951)
400-545		dolomitic marble	SE Ontario (6 localities)	calcite - dolomite	Sheppard (1966, Ph.D. thesis McMaster Univ.)
450		dolomite marble	Gouverneur, N.Y.	calcite-dolomite	Lessing and Grout(1970)
300-400	20-25	calc-silicate rock	SW Quebec; Haliburton-Bancroft, Ontario	feldspar; Geothermal gradient	Shaw, et al (1963)

belt, particularly sodalite, hackmanite, cancrinite, hastingsite, corundum, nepheline and cyrtolite, are found in most major collections of the world.

The nepheline and corundum-bearing gneisses occur as discontinuous, tabular bodies of varied size, irregularly distributed through a NNE-trending belt nearly 120 miles (200 km) long but only a few miles wide, with some local offsets. In relation to the metamorphic pattern of the region as a whole, this belt reflects an intermediate depth of burial and metamorphism. Mineral assemblages are consistent with metamorphism to the high amphibolite facies of Miashiro's low pressure, intermediate type. South of the belt, the metasediments and metavolcanics of the Grenville Group have been weakly to moderately metamorphosed, and were intruded by well-defined granitic stocks with contact aureoles, reflecting high-level emplacement. North of the belt, relics of granulite-facies mineral assemblages are found and the rocks are dominated by migmatites and by large, rather poorly defined, anatectic granitic masses. Differerential uplift, through block-faulting or other mechanisms, may account for the abrupt boundaries of some of the metamorphic zones, and thus for the belt-like configuration of the presently exposed occurrences of nepheline and corundum gneisses.

The mineral assemblages of the alkaline gneisses vary greatly along and across the strike of the foliation, between discrete layers within bodies, and from body to body. The predominant minerals, the relative proportions of which also vary greatly, are nepheline, plagioclase (albite to andesine, and up to three generations within single hand-specimens) scapolite, microcline, calcite, iron-rich biotite, hastingsitic amphibole, soda-rich clinopyroxene, corundum, muscovite, magnetite, grossular-andraditic garnet, and vesuvianite. Many of the alkaline gneisses contain relatively little potash feldspar in comparison to plagioclase, thus are not strictly syenitic in composition, although the term is widely and loosely used to describe all of the alkaline gneisses. Common alteration products include sodalite, cancrinite, natrolite, hydronephelite, and gieseckite. On weathered surfaces, the presence and relative amounts of the major minerals are readily apparent. Corundum stands in higher relief, and nepheline in lower relief, than the feldspars. Scapolite weathers much like nepheline and the two may easily be confused.

The alkaline rocks are generally gneissic and most are conformable in structure and texture with the bedding and foli-

ation of the enclosing gneisses and marbles. Locally, metamorphic recrystallization has destroyed the foliation by forming coarsely crystalline pegmatite-like patches which grade into the parent-gneiss. In such patches, nepheline crystals may reach a length of about six feet (2 m), biotite crystals, three feet (1 m), and corundum crystals, one foot (30 cm). Some transgressive nepheline pegmatites of generally similar appearance occur, and may be of similar origin. With only minor exceptions (a few sharply-bounded dykelets filling joint-cracks in the Blue Mountain mass), corundum has not been found in transgressive bodies in the alkaline gneisses.

Although these alkaline gneisses have been studied for over 70 years, their origin is still controversial. Between 1893 and 1930, these rocks were generally assumed to be of igneous origin. Two opposing factions developed, however: those who would derive the alkaline gneisses by igneous differentiation of granite, and those who favoured the limestone-syntexis theory for desilication of a granitic magma. Replacement structures were occasionally recognized and prompted Osborne, in 1930, to suggest a composite origin in which undersaturated igneous magmas, lit-par-lit injection and metasomatism were all involved. In 1943 Gummer and Burr coined the term "nephelinization" for a pervasive metasomatic transformation of paragneisses into nepheline-bearing assemblages. Since that time, investigators have varied in attributing igneous versus metasomatic origins to various individual occurrences and, in fact, both types are probably present. Nepheline gneisses of possible igneous origin appear to be present throughout the alkaline belt, but have been described only from the west end. These range from melanocratic to leucocratic. Metasomatic varieties are recognized as having formed from a wide variety of Grenville-type supracrustal gneisses and even from some of the early basic intrusive rocks. Nepheline-free intermediate stages in this transformation can be recognized. Little agreement has yet been reached on the nature and source of the nephelinizing fluids, with anatectic melts at depth, nearby granitic magmas, and undersaturated magmas all being considered as progenitors. Also suggested was the desilication and soda-enrichment of solutions through reaction with the prevailing carbonate-rich, silica-poor rocks.

The alkaline rocks are syn-orogenic, the metasomatic varieties being developed from rocks that had already been folded and metamorphosed. All of the varieties were, in

turn, subjected to later periods of folding, intrusion and metamorphism. Most granitic intrusions of the region are younger than the nepheline gneisses and have had a profoundly destructive effect on the early undersaturated rocks. Many of the bodies of white-to-grey nepheline-bearing gneisses have been partly replaced by streaks, margins and amoeboid salients of pink, microcline-rich syenite. In some places, the nepheline-bearing gneisses have been partially altered to masses of coarse microcline with corundum crystals (the "corundum-syenite pegmatites" of earlier literature). The nepheline-rocks were thus much more extensive than at present.

Calcite-cored vein-dykes, lined with well-formed crystals of nepheline, feldspar, biotite, magnetite, and apatite, occur within the nepheline-bearing gneisses. These veins are relatively late in origin, as indicated by their truncation of the foliation. They may have formed by recrystallization of the wall rock along dilated joint-fissures, under the influence of hydrothermal solutions circulating from nearby small, sharply bounded bodies of granite and syenite, which were also joint-controlled.

Retrograde alterations are ubiquitous. Much of the corundum is rimmed by fine-grained muscovite, and in some occurrences, large single crystals of muscovite contain irregular relict cores of corundum. Most of the sodalite and cancrinite are replacements of nepheline, and in the major occurrences of these minerals, their development appears to have been directly related to adjacent small syenitic or granitic bodies. Some sodalite and cancrinite, and probably most of the very common hydronephelite and gieseckite, which have developed outward from joints and fractures, may reflect the gradual reduction in temperature and pressure which accompanied the uplift and denudation of the region.

From about 1900 to 1915, grain corundum was produced from many occurrences in the eastern portion of the belt. Since the mid-1930's, ceramic-grade 'nepheline syenite' has been produced on a large scale at Blue Mountain, a folded sill-like body of leucocratic nepheline gneiss which lies some 25 miles (40 km) southeast of the west end of the alkaline gneiss belt. Several short-lived mines were developed in nepheline pegmatites in the western and central portions of the belt, but the composition of these rocks proved to be too erratic to sustain production of uniform concentrates. Some of the nepheline-gneiss hills just east of Bancroft may be mined in the near future. Sodalite for ornamental and

lapidary purposes has been produced sporadically from one occurrence, which is currently in small-scale production.

Selected references: 1, 2, 4, 8, 11, 20, 22, 23, 24, 27, 29, 55, 56.

Note: No. 55 (Moyd, L., 1949) refers specifically to many of the occurrences being visited. For detailed references to occurrences throughout the nepheline-ocorundum belt see No. 27 (Hewitt, D. F., 1961). Up-to-date references on the petrology of the belt and related occurrences are listed in the guidebook for Excursions A53 and C53. (Gittins, J. and Lumbers, S. B.).

Calcite Vein-Dykes

Throughout the world, crystal-lined, calcite-cored pods and veins are found in basement-complexes in which calcareous rocks are common. In such veins, well-formed crystals of various rock-forming minerals, predominantly silicates, project inward from the walls into the core. Veins of this kind have supplied most of the world's sheet-phlogopite and, prior to the mining of rock-phosphate, most of the apatite; and minor amounts of biotite and fluorite. Many have been explored for uranium and thorium, but without significant production as yet. Such pods and veins are major sources of fine mineral specimens.

In the Grenville of Quebec, Ontario, and New York, thousands of such veins have been mined or explored. The occurrences in this region have been called pegmatite dykes, veins, vein-dykes, layers or xenoliths of skarn, and even mobilized skarns. The term "vein-dykes", proposed by H. V. Ellsworth, is used here because these bodies combine many of the features of both. The hyphenated name serves to distinguish them from true veins and dykes, various types of which are common in the region.

The vein-dykes typically have cores of coarsely crystalline calcite (with or without accompanying fluorite or anhydrite), but otherwise may vary greatly in constituent minerals. The most common major minerals are potassic and sodic feldspars (including perthite, antiperthite, and peristerite), clinopyroxenes (generally diopside-to-ferrosalite), amphiboles (in a similar range), phlogopite-to-biotite micas, scapolite, and apatite. Locally, nepheline, magnetite, or quartz may be major constituents. Occurring in lesser quantities are magnetite, titanite, zircon, quartz, pyrite, and pyrrhotite. Many other minerals may be present in minor

amounts, including tourmaline, epidote, ilmenite, barite, uraninite, thorianite, uranothorite, thorite, betafite, allanite, fergusonite, spencite, and molybdenite. Retrograde and secondary alteration products are common.

Most of the minerals occur as well-formed crystals attached to the vein walls, with free faces developed against the cores. Some minerals also occur as euhedral crystals completely enclosed in the core-material, the most common of these being apatite, phlogopite, and titanite. In most of the veins, crystals range from about 1 inch (2.5 cm) to about 1 foot (30 cm) in length but, in some occurrences, extremely large crystals have developed, with some individual crystals of mica, apatite, and hornblende exceeding several tons in weight.

The type and composition of the vein minerals is generally related to the composition of the enclosing rocks. Thus, nepheline crystals occur in the veins in the nepheline-bearing gneisses; quartz crystals in the veins in quartz-bearing gneisses; lepidomelane in veins in gneisses having iron-rich minerals, but phlogopite (ranging to almost colourless) in iron-poor host rocks; ferrosalite in amphibolites, but diopside in iron-poor calcareous gneisses and in the 'metamorphic pyroxenites' derived from dolomitic limestones. The amphiboles of numerous veins within a radius of a few hundred yards may range from colourless to nearly opaque and black, depending on the immediate host-rocks.

Many vein-dykes are reasonably concordant with the layering and foliation of enclosing gneisses, but others transect these structures. All of the tabular bodies appear to have been developed along bedding planes, joints, or other openings. Sub-parallel sets of veins are common; curving, crossing, coalescing, and pinching and swelling of veins are frequently observed.

Contacts between vein-dykes and wall rocks are gradational. Except for the central core, systematic zoning is usually not very well developed, and the general impression is that of more or less simultaneous rather than sequential development of the various minerals which line the walls. An unusual aspect of the paragenesis of many, if not all, of the vein-dykes is that the crystals which project inward from the walls (as well as those which are completely isolated within the core) are later than and have replaced the core-materials. This anomalous type of vein-development is indicated by the presence of rounded relicts of the core-mater-

ials within the well-formed crystals. Isolated pellets ("marbles") of calcite are common in apatite and hornblende crystals, and have also been observed in titanite, betafite, uraninite, and other minerals.

The tabular vein-dykes are the ultimate stage in a continuous series of transitional forms derived from the parent gneisses. The first and simplest form is that of coarsely crystalline, pegmatite-like patches. These appear to have been developed by localized recrystallization of the constituents of the gneiss, with concomitant destruction of the foliation of the gneiss. There is generally a gradational zone between unaffected gneiss and the coarsely crystalline patch. The major minerals of the coarsely crystalline zone may be nearly identical to those of the parent gneiss, but in some occurrences there have been modifications in composition, and adjustments to different thermodynamic conditions, e.g. the principal dark mineral of the parent-gneiss may be hornblende, whereas that of the coarsely crystalline patch may be biotite or magnetite. The next transitional form is that of pegmatite-like masses which contain small cores of coarsely crystalline calcite (rarely, some fluorite). With increasing size of the core, these bodies take on the appearance and characteristics of typical vein-dykes. The transitional forms may occur as discrete, isolated bodies; but in some occurrences, all types may be represented within a single complex body.

In carbonate-bearing calc-silicate rocks, there are also transitional forms between host-rocks and vein-dykes, and it is difficult to make sharp distinctions. The process of development of diopside, scapolite, and phlogopite metacrysts in coarsely crystalline marble is undoubtedly closely related to that of the development of crystals of the same minerals in calcite veins which transect calcareous and magnesian metasediments. Also, the reaction zones which have developed along contacts between apophyses of marble in gneiss, and around xenoliths of gneiss in flowage marbles, may closely resemble the linings of the vein-dykes.

As in the nepheline- and corundum-bearing gneisses, the locus of the calcite vein-dykes reflects intermediate depth of burial and metamorphism. Vein-dykes are absent from both the weakly to moderately metamorphosed metasediments and metavolcanics of the Grenville Group, and the highly metamorphosed injection gneisses. In fact, there are relatively close associations between many of the vein-dyke occurrences and those of the nepheline and corundum rocks.

In some places, vein-dykes have been developed within nepheline-and corundum-bearing gneisses.

The availability of large quantities of calcareous rocks has undoubtedly been a major factor in the genesis of the calcite-cored pods and vein-dykes. Some of the calcium of the calcite, fluorite and anhydrite of the vein-cores may have been derived directly from these rocks, but no truly intrusive carbonatites appear to be involved. Carbon dioxide, released during the widespread silication of dolomitic marbles, must have added greatly to the fluidity and penetration-power of available hydrothermal solutions, regardless of their origin. The syenitization of amphibolites under the influence of carbon dioxide-enriched solutions could have provided calcium for both the core-materials and common vein-minerals such as apatite, scapolite and titanite.

Although the well-crystallized vein-linings appear to have been formed by hydrothermal 'fluxing' and re-working of the wall rock minerals, the stability range of the vein minerals is similar to that of the minerals of the wall rocks. Because many of the vein-dykes transect well-defined gneissic structures, they must have been formed appreciably later than the initial metamorphism of the host rocks, thereby indicating two separate and distinct periods of metamorphism. During the first period, planar and linear textures were developed in the host rocks. A cooler interval fixed these textures and permitted development of joint systems and fracturing. In the second period, re-heating under static conditions favoured localized development of coarsely crystallized bodies with non-aligned components. The crystal-lined pods and vein-dykes thus appear to represent a form of metamorphic differentiation, with most constituents being of very local origin, and others possibly brought from some distance.

Because the core-materials are far less rigid than the surrounding rocks, the fillings of some of the tabular bodies behaved as 'lubricants' in the relief of differential regional stresses. In the cores of small pods surrounded by solid rock, and in sheltered 'bays' in some of the larger veins, anhedral crystals of undisturbed calcite or anhydrite may reach 3 to 4 feet (1 m) in diameter. In the vulnerable 'mainstream' of some vein-dykes, however, the core-material has been mylonitized, with development of augen and complex flowage patterns. Flow structures have formed around crystals which project from the walls, and around rigid materials caught up within the core, whether of blocks

and crystal fragments torn from the walls, or isolated crystals that had originally grown within the core.

Post-glacial weathering and erosion have leached the calcite from near-surface portions of many vein-dykes, leaving debris-filled trenches. Well-formed loose crystals, some still remarkably fresh and brilliant, can be recovered from the soil which fills these trenches, as well as from the exposed walls of the veins.

Selected references: 1, 9, 14, 26, 50, 62, 69, 72, 74, 75, 76, 78.

PART 2

MINERAL COLLECTING LOCALITIES

The excursion area has been divided into six sections which are, in the order of their visit and description: (1) Gatineau River area, (2) Perth area, (3) Otter Lake-Ottawa River area, (4) Madawaska Valley area, (5) Bancroft area and (6) Wilberforce area. These are outlined in Figure 1. More detailed figures, on which the individual mineral localities are plotted, are provided in the text. Note that sections (1) and (3) are included in a single figure. Each section is introduced by a few notes of general interest, and the mineral localities are then described individually. Most localities are accessible by auto transport, though some access roads necessitate the use of high-clearance vehicles. One locality is accessible by a foot path approximately ½ mile (1 km) long, and one requires transportation by boat. Many of the localities are surrounded by dense bush. Weather and other factors may affect the order in which the localities will be visited.

GATINEAU RIVER AREA

The region north of Ottawa, drained in part by the Gatineau River, is underlain mainly by metamorphic and igneous rocks of the Grenville Group. These rocks are separated by a series of faults from flat-lying Palaeozoic sandstones, limestones and shales to the south, that underlie the city of Ot-

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Fig. 4. Mineral localities, Gatineau River and Otter Lake-Ottawa River region, Quebec.

1—Fortune Lake, 2—Champlain Lookout, 3—McCloskey's Field, 4—Stephen Cross Quarry, 5—Maxwell Quarry, 6—Evans-Lou Mine, 7—Leduc Quarry, 8—Vavasour Mine, 9—Kirkham Molybdenite prospect, 10—Yates Uranium Mine, 11—Bryson Roadcut, 12—Chenaux Rapids Dam. (Opposite page).

HURON
10
9
11
12
8
7
6
5
4
3
2
1
GATINEAU
PARC
OTTAWA
HUL
RIVER
PACIFIC
Miles
Kilometres

tawa. Late Pleistocene marine sands, silts and clays blanket much of the lowland area. The Precambrian rocks, mineralogically the most rewarding, are described by Ells (1907), Wilson (1920), Béland (1954), Sabourin (1965) and Hogarth (1970a); the Palaeozoic geology by Wilson (1946); and the Pleistocene geology of Johnston (1917) and Gadd (1962).

Field trips to the Gatineau River area, and to the Otter Lake - Ottawa River area, will emanate from Ottawa, the capital city of Canada. Ottawa was originally named Bytown, in honour of Colonel John By of the Royal Engineers who, in 1826, undertook construction of the Rideau Canal that now transects the city. In 1855 the name Bytown was changed to Ottawa, after the Outaouais, a band of Algonkian-speaking Indians. In 1857 Queen Victoria selected Ottawa as the capital for United Canada. Greater Ottawa today has a population of approximately 430,000, with the federal civil service composing a large proportion of the working community. The city has had the advantage of planned development since 1899, which is reflected particularly in its many parks and scenic drives.

Bytown (Ottawa) has found a niche in mineral nomenclature: the mineral bytownite was named in 1836 by Dr. Thomas Thomson, distinguished mineralogist and Regius Professor of Chemistry at the University of Glasgow, for a plagioclase feldspar collected by Dr. Arthur Holmes of Montreal from a boulder near Bytown. The original specimen has since been indicated to be labradorite, but through Tschermak's adaption the name is used to define plagioclases which lie between labradorite and anorthite.

The Gatineau River flows southward through heavily wooded terrain to join the Ottawa River about 1.5 miles (2.4 km) east of Hull. Calcite vein-dykes were at one time important sources of apatite and phlogopite in the Gatineau River area and contributed to its early settlement (Hogarth, 1962). More recently, brucite, magnetite and feldspar have been produced.

The first three localities to be visited in this area lie within Gatineau Park, an 88,000-acre area immediately north of Hull that is maintained and administered by the National Capital Commission, an agency of the federal government.

Fortune Lake (Locality 1, Figure 4)

Black yttrian andradite is a characteristic mineral in pegmatites cutting rocks of the Wakefield batholith and neighbouring metasedimentary rocks (Kasowski and Hogarth,

1968). The pegmatites, occurring throughout a zone 2.5 miles (4 km) wide and 3.5 miles (6 km) long, are composed almost entirely of oligoclase, microcline and quartz. Most crystals of andradite are in those parts of the pegmatites enriched in plagioclase. Other yttrian minerals are almost completely lacking.

At Fortune Lake, an officially marked stop on the Gatineau Parkway, 13 miles (21 km) from the south entrance of the Park, pegmatite dykes cut through syenite, breccias and calc-silicate rock. One of these dykes, about 25 feet (7.5 m) wide, exposed in a roadcut 800 feet (240 m) east of the parking area, contains considerable yttrian andradite (1.0 - 2.2% Y) in its hanging-wall side, although the narrow border zone of graphic granite is nearly free of andradite. Andradite dodecahedra 4 inches (10 cm) across have been found at this location.

A rather unusual composition of the yttrian garnet is evident from chemical analyses, which show the garnet to be low in manganese and almost devoid of lanthanides. The composition of betafite from a nearby breccia (Hogarth, 1961, sample H914) shows little correlation in yttrium and lanthanides (ΣY_2O_3 Tr., ΣCe_2O_3 0.3%) and probably represents a different mineral generation.

Champlain Lookout (Locality 2, Figure 4)

The Champlain lookout is on the Gatineau Parkway, 14.5 miles (23 km) from the south entrance of the Park. The lookout is situated on the crest of the Eardley escarpment which sharply separates the hilly country to the north from the Ottawa Valley Plain 750 feet (235 m) below and to the south. This escarpment is generally believed to represent a fault scarp marking the northern limit of the Ottawa graben. Recent data suggest that the escarpment may be the manifestation of two fault systems trending northwest and east-west (Hogarth, 1970a).

In the Ottawa Valley Plain, Precambrian syenite gneiss crops out to the southwest, whereas Ordovician sedimentary rocks are found to the south and southeast, though only poorly exposed in creek beds and excavations. The Ottawa Valley Plain is, in most places, covered by clay deposited by the post-glacial Champlain Sea.

The Champlain lookout is at the north side of a large roof pendant of metamorphic rock (mainly calc-silicate rock or metapyroxenite and diopside gneiss) in syenite, monzonite and aplite of the Wakefield complex. The S-shaped fold of

this roof pendant is tight and plunges northeastward at 25°. Roadcuts in the neighbourhood of the lookout expose calc-silicate rocks and associated pink calcite veins containing diopside, actinolite, phlogopite and pyrite and rare molybdenite, pyrrhotite, uraninite, titanite (sphene) and apatite.

McCloskey's Field (Locality 3, Figure 4)

Intrusive carbonates are common in rocks of the Wakefield batholith near its southern margin, and good exposures of carbonate dykes are to be seen in McCloskey's Field on the proposed extension of the Gatineau Parkway, 1 mile (1.6 km) beyond the Champlain lookout. These dykes are dolomitic to calcitic and contain considerable apatite. Betafite, remarkable for its almost complete lack of rare earth elements, occurs sparingly. Other minerals present in the dykes include magnetite, pyrite, pyrrhotite, barite, phlogopite, Na-actinolite, strontianite, rutile and fluorite. The carbonates are rich in strontium (calcite up to 1.5% SrO). The calcite-dolomite geothermometer gave temperatures of 560 and 610°C for two samples of rehomogenized calcite (A. S. Wong, 1971, M.Sc. thesis, Univ. of Ottawa).

A well defined fenite of Na-amphibole and phlogopite surrounds these rocks. Calcite bodies are surrounded by eckermannite and normally pleochroic phlogopite; dolomitic bodies by richterite and reversely pleochroic phlogopite or ferriphlogopite (Faye and Hogarth, 1969; Hogarth, Brown and Pritchard, 1970).

The fenites show a K/Ar date of 920 m.y. Additional information on these and related rocks will be found in Béland (1951), Hogarth (1966), and in the guidebook for Excursion B26.

Stephen Cross Quarry (Locality 4, Figure 4)

The Stephen Cross quarry was worked for brucite from 1959 to 1968 by the Aluminum Company of Canada. The quarry is immediately west of the Gatineau River road at a point 2.5 miles (4 km) north of its junction with Quebec Highway No. 11. The brucitic marble body is approximately 800 feet (240 m) long and 650 feet (200 m) wide. It is completely enclosed in syenite and monzonite of the Wakefield batholith (Fig. 5) and has been quarried to a depth of about 90 feet (27 m) on 4 levels.

The geology has been discussed in detail by T. Hoy (1970, M.Sc. thesis, Carleton Univ.) and much of the following information is a summary of this work.

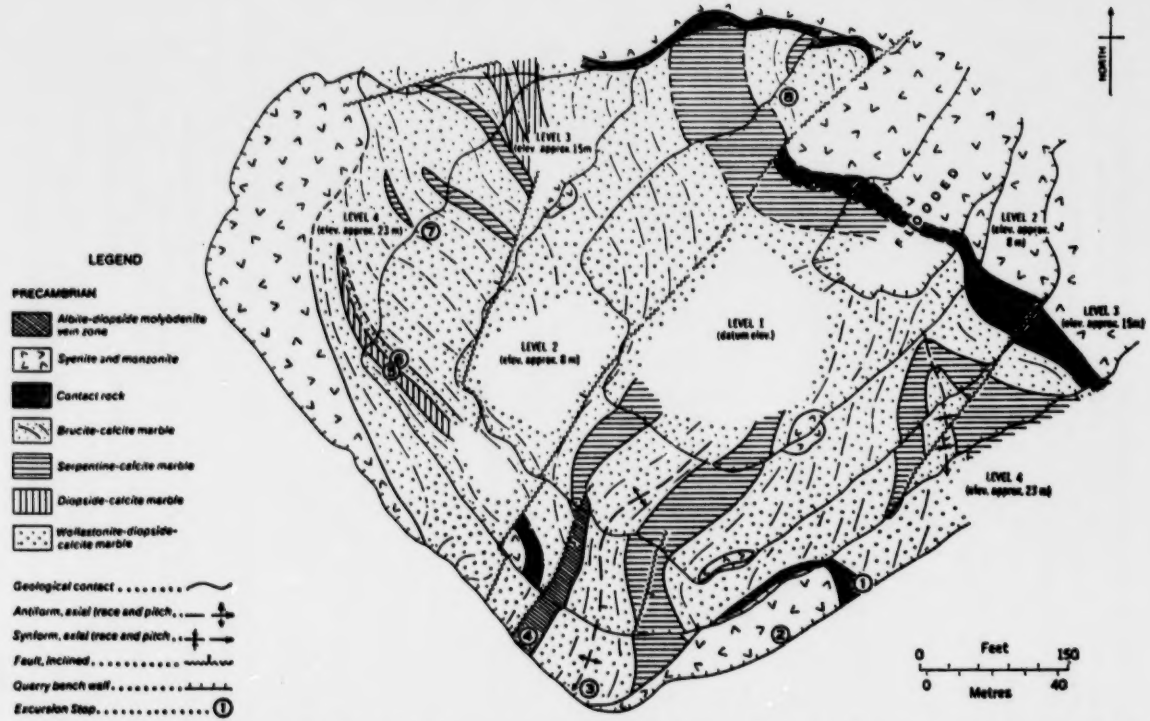


Fig. 5. Geological map of the Stephen Cross quarry, Wakefield, Quebec (T. Hoy, Carleton University and D. D. Hogarth, University of Ottawa).

Brucite, in nodules averaging 2 mm in diameter, and commonly with a micro onion-skinned texture, occurs in calcite marble and serpentinized forsterite-calcite marble. The serpentinized forsterite rarely encloses spinel.

Interlayered with the brucitic marble, particularly in the northeast part of the quarry, is marble without brucite to which Hoy assigns the following subdivisions:

serpentine + calcite
diopside + serpentine + calcite
diopside + calcite
wollastonite + calcite + diopside

The diopside in this marble contains local concentrations of spinel crystals, greenish in thin section and up to 1 inch (2.5 cm) in diameter.

The marble has undergone intensive folding and faulting. Some faults are open, but others are sealed with calcite or fibrous brucite. Fractures subparallel to faults are commonly healed with calcite and coarse, platy brucite; others contain pyroaurite, aragonite and calcite. Interlayers of comparatively brittle rock have been contorted and boudinaged, the boudins being subsequently altered by metamorphic differentiation and serpentinization.

Reaction zones, up to 30 feet (10 m) wide, are developed at the contact of marble and syenite. In these zones the following mineral assemblages have been noted:

diopside + calcite + phlogopite
wollastonite + diopside + graphite ± grossularite
diopside + scapolite + calcite
magnetite + chondrodite + calcite + dolomite + spinel
brucite (lamellar) + grossularite + diopside
datolite + diopside + tremolite + plagioclase
andradite + calcite + quartz
andradite + diopside + calcite ± clinozoisite

Titanite is commonly associated with all assemblages. Rare quartz-prehnite veinlets cut these rocks.

Brucite is thought to have been derived by contact metamorphism of dolomitic limestone during the intrusion of the Wakefield syenite batholith. Hoy believes that most has been derived through complete hydration of periclase, suggesting the following reactions.

(1) $Ca\,Mg\,(CO_3)_2 \rightarrow Ca\,CO_3 + MgO + CO_2$
(dolomite) (calcite) (periclase)

(2) $MgO + H_2O \rightarrow Mg(OH)_2$
(periclase) (brucite)

Coarse brucite in faults and fractures may have been derived by direct hydration of dolomite according to the following reaction:

(3) $Ca\ Mg\ (CO_3)_2 + H_2O \rightarrow CaCO_3 + Mg(OH)_2 + CO_2$
(dolomite) (calcite) (brucite)

Some brucite, however, has been derived by hydration of forsterite:

(4) $2Mg_2\ SiO_4 + 3H_2O \rightarrow Mg(OH)_2 + Mg_3Si_2O_5(OH)_4$
(forsterite) (brucite) (serpentine)

The brucitic marbles have survived a regional (Grenvillian) metamorphism, which has imposed a weak fabric on the syenite and monzonite.

In addition to the minerals noted above, the following species have been recorded from this quarry: apatite, chlorite, epidote, hydrotalcite, hydromagnesite, molybdenite, chalcopyrite, pyrrhotite, schorl, and tremolite-actinolite. The mineralogy has been described by Sabina (1970, pp. 41-42).

The following locations within the quarry will be visited (Fig. 5): (1) contact rock containing coarse wollastonite, (2) monzonite of the Wakefield batholith, (3) a small antiform traced by boudins of diopsidic rock, (4) albite-diopside-molybdenite rock, (5) granular green-to-white diopside rock, (6) wollastonite-diopside rock, (7) boudins of sky-blue diopside, and (8) foliated brucite and pseudomorphs of serpentine after forsterite.

Maxwell Quarry (Locality 5, Figure 4)

The Maxwell brucite deposit lies 1.5 miles (2.4 km) north of the Cross quarry and was mined from 1942 to 1967 by the Aluminum Company of Canada. The marble body was originally 900 feet (275 m) long with a maximum width of 400 feet (120 m) and a depth of 650 feet (200 m) below the highest point.

The brucite occurs as small (1 mm) nodules in calcite-marble, which is enclosed in syenite. Rock types here are similar to those described for the Stephen Cross quarry, and the previous remarks on genesis also apply.

Of special interest at the Maxwell quarry are roof pendants of calc-silicate rock, which are infolded and boudinaged in the upper part of the deposit. These are well ex-

posed on the southeast wall of the quarry. Some of the calc-silicate rocks contain cores of pink calcite with coarse phlogopite and apatite. Locally, the surrounding marble is a serpentine-hydrotalcite-calcite rock which, in one place, contains geikielite (Hounslow and Chao, 1967).

Serpentine occurs in a variety of hues. Associated with the serpentine are lenses of mauve, green and blue granular diopside. Coarse, foliated brucite and calcite fill some fractures in marble.

Some 30 minerals have been found to date in the quarry. Of particular interest are blue celestite crystals; long-fibre chrysotile; spinel, in octahedra up to 1.5 cm; and forsterite, as crystals up to 15 cm. The deposit has been described by Goudge (1939, pp. 39-41), Ambrose (1943) and Sabina (1970, pp. 42-44).

Evans-Lou Mine (Locality 6, Figure 4)

The Evans-Lou mine is a feldspar quarry in granite pegmatite. It lies 1.4 miles (2.3 km) east of the Cantley-Poltimore road at a point 2.3 miles (3.7 km) south of Poltimore. The pegmatite is up to 75 feet (23 m) wide and has been traced along the crest of a ridge for 400 feet (120 m). It was mined for feldspar and quartz intermittently between 1934 and 1956, most of the work being done from 1938 to 1952 by Canada Flint and Spar Ltd.

In August 1970, 33 feet (10 m) of water was drained from the pit by the University of Ottawa in order to study mineral associations in place.

The pegmatite cuts quartz monzonite, quartz diorite and calc-silicate rock. There is a normal but asymmetric sequence of zones, the following being recognized: quartz core, perthite-quartz, perthite-plagioclase-quartz and, on the periphery, graphic granite. Further details of geology are given by Miles, Hogarth and Russell (1971).

About 60 minerals have been identified from the Evans-Lou Mine. Most of the rare-element minerals are concentrated in the perthite-quartz zone close to the quartz core. These include the bulk of the niobium, yttrium, uranium and thorium minerals. Bismuth minerals have been found in the quartz core only. It is remarkable that over half the species are secondary. At present (mid-1971) 11 minerals remain unidentified.

Fergusonite ($YNbO_4$) and hellandite [$(Y, Ca)_2 (Si, B, Al)_3 O_8.H_2O$] are common primary minerals, the former partly

oxidized to a yellow X-ray-amorphous stain, xenotime (YPO_4) and uranium silicates, and the latter to tengerite [$Y_2(CO_3)_3.3H_2O$], thorogummite and several other secondary minerals (Hogarth, 1970). The new mineral wakefieldite (YVO_4) seems to be among the breakdown products of hellandite (Miles, Hogarth and Russell, 1971).

Although the best collecting was available in the now inaccessible portion of the pit, nearly 50 minerals have been identified from the dump.

Leduc Mine (Locality 7, Figure 4)

The Leduc mine, a quarry in zoned pegmatite about 40 feet (12 m) wide, was worked for mica in 1885 and for gem tourmaline in 1908 (de Schmid, 1916). It is accessible by a half-mile (1 km) trail leading southward from the road branching off the Cantley-Poltimore road at a point 2.5 miles (4.0 km) west of the intersection. The dyke (Fig. 6) has a quartz core; an intermediate zone of elbaite, amazonite, cleavelandite and quartz; and a wall zone of schorl, pink perthite and quartz. Near the periphery there is a lens of medium-textured pegmatite characterized by smoky quartz, peristerite and biotite and a border zone of graphic granite. The main pit is about 65 feet (20 m) long; a second pit lies 125 feet (38 m) to the north.

Of particular mineralogical interest are large (up to 50 cm) books of lithia mica in the intermediate and wall zones. Complete analyses of the mica are given by Hoffmann (1901), Stevens (1938) and Winchell (1942). According to Winchell the mica contains about 15 per cent protolithionite ($K_2Li\ Fe_4\ Al_3\ Si_6\ O_{20}F_4$) molecule and should therefore be termed zinnwaldite. The analyses indicate 6 to 13 percent muscovite which Winchell believed to be an interleaved component. Green and pink tourmaline are fairly abundant, though seldom of gem quality. Other interesting but infrequently encountered minerals are uraninite, in cubes up to 1 cm across; thorogummite; cyrtolite, as crystals up to 1 cm in diameter; euxenite; pinacoidal (short prismatic) green beryl; large subhedral crystals of yellowish topaz and rose-coloured octahedra of fluorite.

Vavasour Mine (Locality 8, Figure 4)

The Vavasour Mine lies one half mile (1 km) off the Cantley-Poltimore road, 5.7 miles (9.2 km) north of the Gatineau River crossing. The mine, known also as the Nellis or Gemmill mine, was originally worked for apatite by Donald

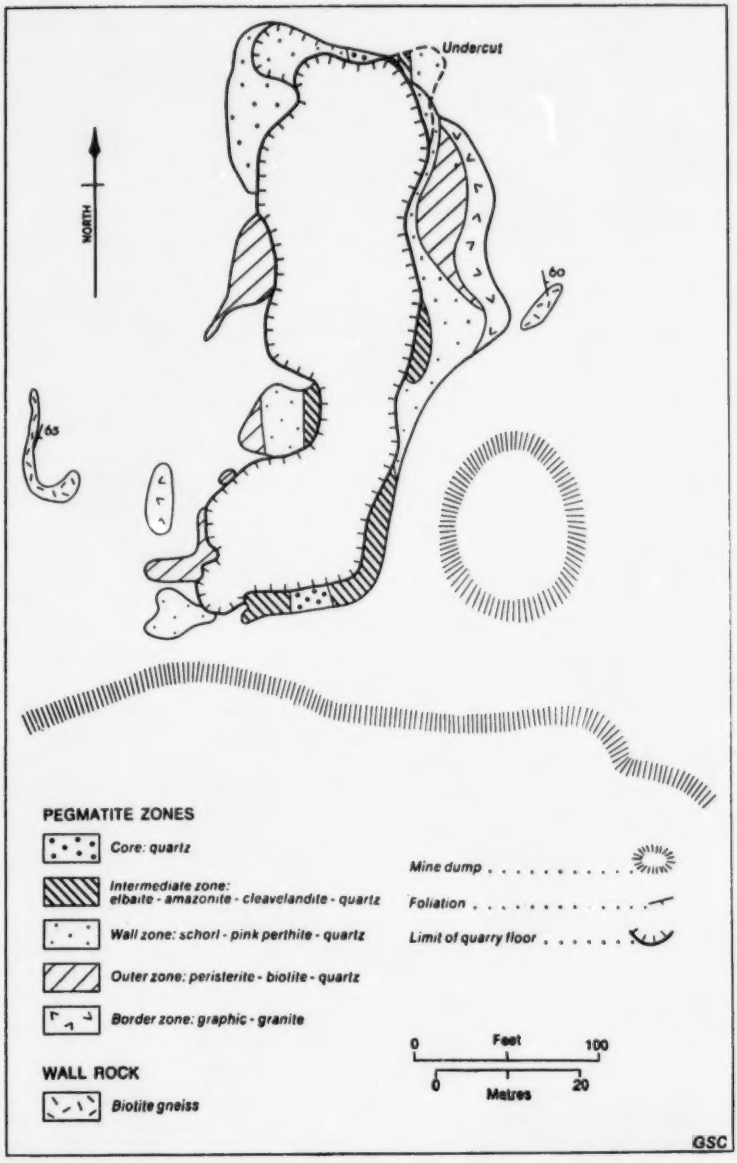


Fig. 6. Geological map of the Leduc mine, Wakefield township, Quebec.

Gow of Cantley in 1878, and subsequently for mica or apatite. From 1936 until cessation of operations in 1964 the mine was operated for mica by Blackburn Brothers Limited and since about 1940 was the principal mica producer in the province. The workings extend to a depth of 180 feet. The Vavasour was the last of the mica-apatite mines of the Gatineau-Lièvre district.

Mica occurs on 2 hills rising 75 and 125 feet (25 and 40 m) above the Gatineau Valley Plain. Most mica has been mined from the north hill. Further descriptions are given by de Schmid (1912, pp. 97-99), Stansfield (1913, pp. 111-114), Spence (1920, pp. 84-86), and Sabina (1970, pp. 18-19).

At the Vavasour mine, the structure is basin-shaped with diopside-rich calc-silicate rock ("gabbro" of Stansfield, "pyroxenite" of de Schmid) overlying biotite gneiss ("Ottawa gneiss" of Stansfield). The biotite gneiss contains varied amounts of pyroxene and in places is coarse grained ("gabbro pegmatite" of Stansfield). Mineral lineations and minor folds plunge northwestward at about 30°.

Veins, or 'vein-dykes', faulted in places, transect the foliation. They strike 0-40°, and fan outwards towards the southwest. With but one known exception, the veins dip steeply eastward. On the north hill, numerous veins are spaced at intervals of about 15 feet (5 m) but there are eight major leads about 100 feet (30 m) apart. The longest lead can be traced for 750 feet (230 m); the main or most productive lead is continuously traced for 400 feet (120 m). The vein system is exposed for 1,300 feet (400 m), but reappears on the south hill 1,500 feet (450 m), distant. Many veins; and actinolite, hornblende, calcite, pyrite, pyrrhotite, followed inwards by layers of phlogopite crystals, green apatite and, finally, coarse pink calcite in the core. Pyrite, actinolite, fluorite, microcline and barite also occur in the veins; and actinolite, hornblende, calcite, pyrite, pyrrhotite, microcline, andesine, scapolite, titanite, graphite and schorl in the calc-silicate rocks.

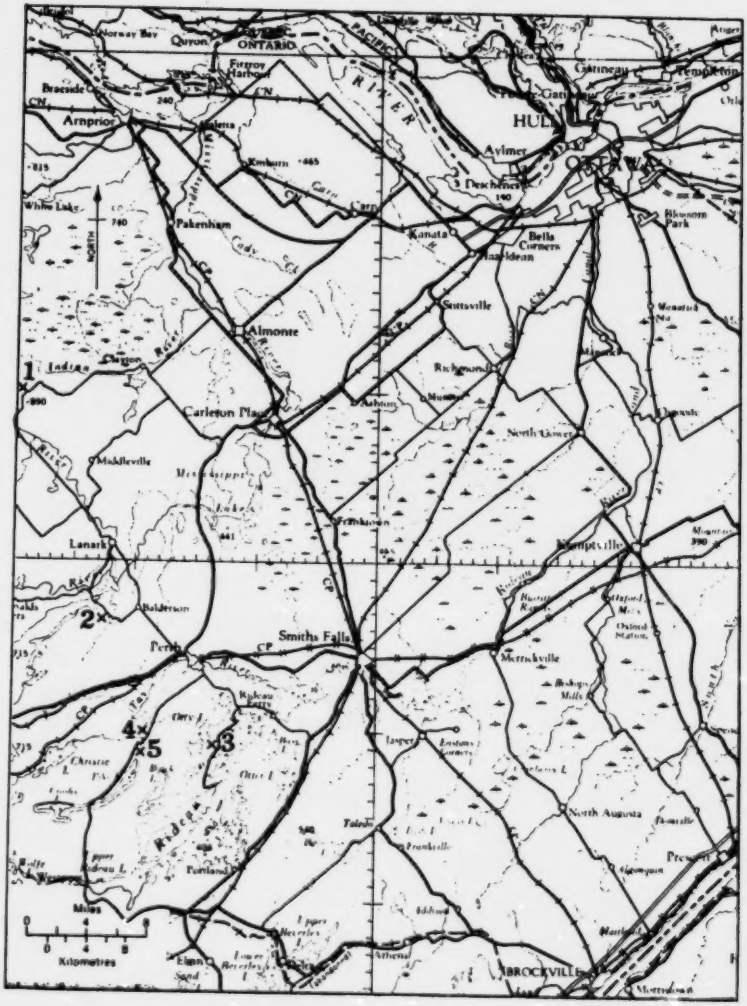
PERTH AREA

The county town of Perth is situated about 50 miles (80 km) southwest of Ottawa on the contact of formations of Palaeozoic and Precambrian age. The town, established for military defence in Upper Canada in 1816, currently has a population of 5,600. The record of part of the town's Scottish ancestry is preserved today in its name and in its many fine stone homes and buildings. The rocks and minerals of

the Perth area attracted the attention of the geologists of the pre-Confederation (1867) era, among whom were Logan, Murray and Hunt of the Geological Survey of Canada, then located in Montreal. A Perth medical man and ardent mineral collector, Dr. James Wilson, drew attention in the 1830's to occurrences of apatite and phlogopite, and the 'new minerals' peristerite, perthite, and (since discredited) wilsonite and raphilite. The names peristerite and perthite were introduced by Thomson (1843, p. 189), wilsonite by Hunt (1853, pp. 168-170) and raphilite by Thomson (1843, p. 153). Bytownite was also subsequently noted in place in the Perth area.

The Perth area became a source of apatite (1855-1947), phlogopite mica (1860-1947), titaniferous magnetite (1860-1971), graphite (1870-1919), feldspar (1900-1954), vermiculite (1960-1965), and marble (1967-1970). Most of the mines were small and most have long since been abandoned to become an almost forgotten part of the area's history. Some of the weathered pits and overgrown dumps still provide observation and collecting sites for those interested in the geology and mineralogy of the area. Excellent specimens of microcline, plagioclase, peristerite (moonstone), perthite, phlogopite and vermiculite may still be collected near Perth. Crystals of zircon, titanite, spinel, corundum, datolite and cenosite, once reported in abundance are now difficult to find.

Apatite and phlogopite, occurring chiefly in vein-dykes and pockets within or marginal to bodies of 'metamorphic' pyroxenite and metamorphosed crystalline limestone and gneiss, were important commercial commodities, particularly in the late 1800's. About 40,000 tons of apatite and about 8,000 tons of phlogopite are believed to have been recovered from deposits near Perth during the period of their mining, from 1850-1950. The Pike Lake mine, opened in 1860, is reported to have supplied sheet mica for use in the battleships of the French fleet of that era, crystals several feet in diameter having been recovered. The Perth area granite pegmatite dykes have been a prolific source of potash spar (microcline), soda spar (albite-oligoclase), and quartz, for industrial uses from 1910 to 1954 (Hewitt, 1967). During this period about one-half million tons of these minerals, valued at about four million dollars, were produced, mainly from four large dykes, of which three are in Bathurst Township.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Braeside
Arnprior
Renfrew
Eganville
Barry's Bay
Golden Lake
Pembroke
Petawawa
Chalk River
Deep River
Mattawa
Cobden
Pakenham
Almonte
Carleton Place
Middleville
Lanark
Perth
Smiths Falls
Kemptville
Merrickville
Prescott
Brockville
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Morrisburg
Iroquois
Winchester
Chesterville
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Oxford Station
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Mississippi R.
Madawaska R.
Bonnechere R.
Petawawa R.
Indian R.
Clyde R.
Jock R.
Gatineau R.
Rideau Lake
Big Rideau Lake
Upper Rideau Lake
Newboro Lake
Westport
Portland
Delta
Elgin
Athens
Toledo
Frankville
Jasper
Eastons Corners
North Augusta
Prescott
Morrisburg
Iroquois
Winchester
Chesterville
Winchester Springs
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Lanark Blue Marble Quarry (Locality 1, Figure 7)

This marble quarry is located near Tatlock, north of Lanark in Darling Township, on an extensive belt of crystalline limestone of the Grenville type that occupies much of the township. It was opened in 1962 by Omega Tile and Terrazo Limited, and operated until 1971. The quarry consists of several pits cut in a zone of predominantly blue marble about 40 feet (12 m) thick, which strikes northwesterly and dips steeply to the northeast. The zone is underlain by a footwall band of hornblende-biotite schist, and overlain by a hanging-wall zone of interbedded tremolite- and diopside-bearing, grey, white, and greenish crystalline limestone, succeeded by blue marble carrying numerous boudins of dark green, partly serpentinized pyroxene-bearing rock. The marble of the hanging wall zone is spotted with pyrite partly oxidized to limonite, which, together with serpentine and hematite, imparts a brownish tint to the rock. Magnificent exposures of the marble, particularly the Lanark blue type, are to be seen in the workings. The first pit to be reached from the road exposes a banded, sky-blue tinged marble. The second and main pit, about 200 feet (60 m) along strike to the northwest, and about 50 feet wide, 65 feet long and 35 feet deep (15 by 20 by 11 m), exposes smooth sawn surfaces of the blue, white and grey marble to good advantage.

About one mile (1.6 km) to the south, the Temple White Marble quarry, of Angelstone Limited, was opened in 1962 on white crystalline limestone and operated until 1971. This uniform white marble consists mainly of coarsely crystalline calcite with minor amounts of diopside and tremolite. In the stripped area of the quarry near the road, small dykes of granitic composition cross-cut altered dark inclusions of basic rock that appear to represent basic dykes in the marble.

Perth and Keays Feldspar Mines (Locality 2, Figure 7)

The Perth and Keays feldspar mines are located in Bathurst Township approximately 3 miles (4.8 km) west by road from Balderson. The mines consist of two pits developed on a simple zoned granite pegmatite, which is traceable for more than one-quarter mile (0.4 km) cutting across banded granitic gneisses with sharply defined contacts (Fig. 8). The water-filled pit at the roadside was known as the Perth mine and operated from 1922-26, producing some 5,000 tons of microcline. Along the strike of the dyke, on a low hill 600 feet (180 m) to the north, a second pit, known as the

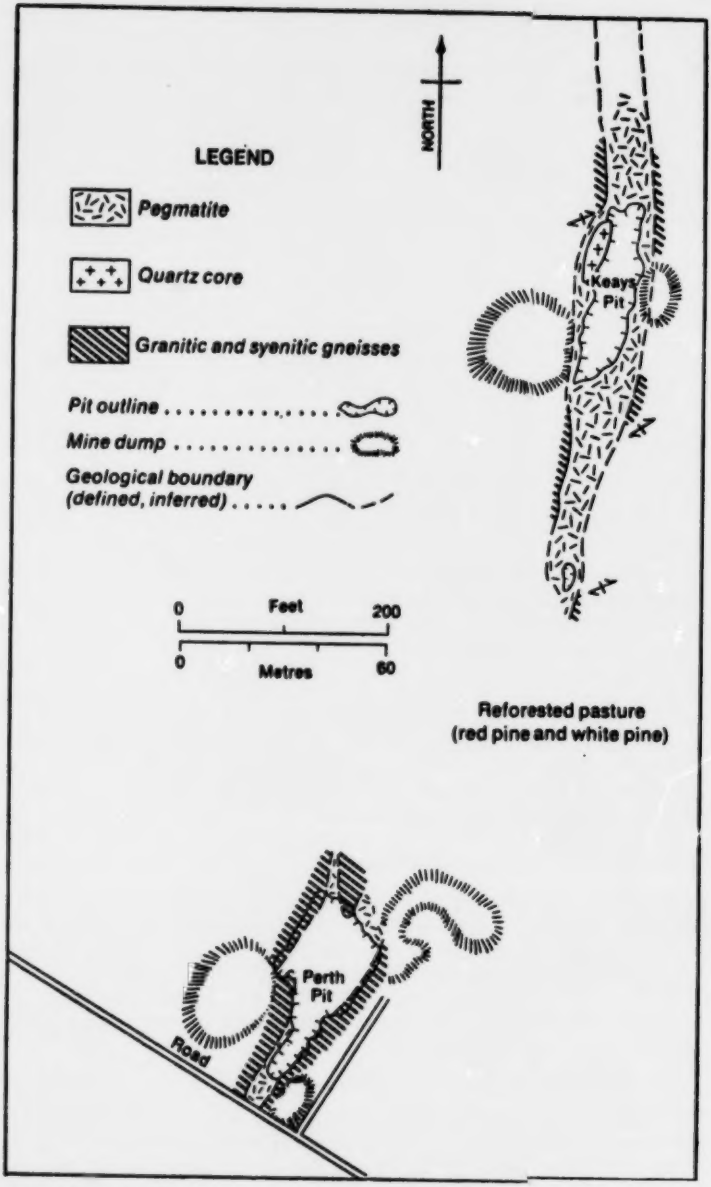


Fig. 8. Geological map of the Perth and Keays feldspar mines, Lanark County, Ontario.

Keays mine, produced about 20,000 tons of feldspar during the same period. Specimens of microcline (microperthite) and peristerite are readily available on the dumps, though both are more abundant at the Keays pit than the Perth pit. The iridescent feldspar within these dykes was first taken to be labradorite, but was named peristerite by Thomson (1843) from a sample sent to him by Dr. James Wilson of Perth through Dr. Arthur Holmes of Montreal.

Perthite Occurrence (Locality 3, Figure 7)

The name "perthite" was given by Thomson (1843) to a whitish aventurine feldspar intergrowth that had been taken by Dr. James Wilson from an outcrop believed to be in Lot 3, Range VI of North Burgess Township. T. Sterry Hunt visited the perthite locality in company with Dr. Wilson in 1847, and subsequently (Hunt, 1852) gave the results of two chemical analyses of the feldspar, concluding that it was orthoclase of higher than average soda content. According to Dana it was later indicated by Gerhard to consist of interlaminated orthoclase and albite.

A perthite-bearing pegmatite dyke at the roadside in North Burgess township, which may be the perthite locality visited by Hunt and Wilson in 1847, will be visited on the excursion. The occurrence is 4.0 miles (6.4 km) along the road leading southward past Otty Lake from the Perth-Rideau Ferry highway. Perthite at this locality consists of semi-parallel bands and irregular lenticles, a few millimetres in width, of light-coloured soda plagioclase (albite-oligoclase) interlaminated in a flesh-red to reddish brown potash feldspar (microcline-orthoclase) host, the texture being readily apparent on prismatic cleavages. Perthite of this nature occurs in cleavage masses as much as 12 inches (30 cm) across in the interior zone of the dyke.

The potash feldspar in all of the pegmatite dykes of the area is probably of perthitic or microperthitic nature. In twenty-eight analyses of commercial potash feldspar from Ontario mines, the albite content ranged from twelve to twenty-five per cent (Spence, 1932), i.e. a soda content high enough to indicate that the samples were perthite, microperthite or anorthoclase.

Vermiculite of the Stanleyville Area

Vermiculite is a distinct mineral species, though the name is now generally applied to mixtures of minerals that exfoliate on heating. It was first noted in the Stanleyville area

in 1950 in samples of micaceous schist and impure crystalline limestone south of the old Pike Lake mica mine, about 8 miles (13 km) southwest of Perth, by C. G. Bruce of the federal Mines Branch. Subsequently an attempt was made to outline and develop the deposits in the 1955-65 period, but this was not successful. The "vermiculite", which has a mixed-layer structure with phlogopite, occurs erratically as an alteration (hydrated) product of phlogopite, in colours ranging from dark green or black, brown to red or silvery tan. In general the light coloured varieties appear to be more highly hydrated, leathery in appearance and most readily expandible. Vermiculitization of the mica appears to have progressed inward from the outside. The origin of the vermiculite is controversial. As a result of his studies of mica deposits of Canada, Hoadley (1960) concluded that the mineral is formed by hydrothermal alteration of mica rather than by surface weathering by meteoric solutions, and that the apparent relationship between vermiculitization and present land surfaces in some deposits is fortuitous and without genetic significance. Vermiculitization of the phlogopite appears to have been related to the intrusion of aplite dykes and veinlets in many places in the Stanleyville area. According to Hoadley (1960), a later phase of hydrothermal activity produced widespread serpentinization and talcification in part of the Stanleyville vermiculite occurrences.

Farrel Vermiculite Occurrence (Locality 4, Figure 7)

The Farrel occurrence is in North Burgess Township, about 1 mile (1.6 km) north of Stanleyville, on the Stanleyville-Perth Road. At this occurrence, the vermiculite is dark green or reddish, and together with coarse brown phlogopite forms a zone of mica schist associated with a pegmatitic intrusion in a belt of impure and altered crystalline limestone.

As exposed in a shallow pit west of the road, banding in the friable, dark weathered, vemiculite-phlogopite bearing, crystalline limestone strikes at 25° and dips 80° to near vertically to the northwest. Around the pit exposures of milky quartz, pegmatite, and hematite-stained pyroxenite may be seen, along with jasper, reddish and greenish vermiculite and brown phlogopite.

Pike Lake Vermiculite Occurrence (Locality 5, Figure 7)

About 1 mile (1.6 km) southwest of the Farrell occurrence along the road to Westport, and 300 feet (90 m) southeast of the road, near the north tip of Pike Lake, a circular pit

about 30 feet wide and 20 feet (9 by 6 m) deep has been made to test an occurrence of vermiculite-phlogopite. The micas occur at the contact of a narrow, folded and brecciated band of altered crystalline limestone, metamorphic pyroxenite, hematite-stained granitic gneiss and an intrusion of pink granite. Reddish and greenish vermiculite and phlogopite form a zone about 4 feet (1 m) wide in altered metamorphic pyroxenite along the crystalline limestone granite contact. Coarse, broken phlogopite crystals are enveloped by fine-grained greenish vermiculite, accompanied by reddish vermiculite, hematite-stained carbonate (calcite, ankerite), diopside and serpentine.

OTTER LAKE - OTTAWA RIVER AREA

The route from Hull to the village of Otter Lake follows the historic Ottawa Valley. In 1613, the French explorer, Samuel de Champlain, was the first to record a voyage up the Ottawa River, travelling northwest to Morrison's Island, some 70 miles (110 km) above the present city of Ottawa. In succeeding years the French, under various companies, used the Ottawa River as a fur trade route and, until 1663, when Louis XIV reorganized the government of Canada, fur traders virtually ruled the country. After the fall of Quebec in 1759, the British became active in the fur trade, particularly through the North West Company and Hudson's Bay Company, which were merged in 1821.

In the beginning of the 19th century lumbering became important and was the principal industry throughout the century. The industry was given a tremendous impetus by demands of the British Navy for squared timber during the Napoleonic Wars.

The first settlement (1786-1800) on the Ottawa River was that of Joseph Mondion at a location on the north shore 28 miles (45 km) above present Ottawa. In 1800, Philemon Wright and associates settled in Wrights Village, which later became the city of Hull. Additional information on the history of the upper Ottawa Valley is given by Kennedy (1970).

A prominent topographic feature to be seen en route, particularly between Breckenridge and Eardley, is the Eardley escarpment, referred to in the Champlain lookout locality. Some interesting Pleistocene features may also be seen on this route, particularly those resulting from sedimentation and erosion by the Champlain Sea (11,500 to 9,500 years B.P.). Near Breckenridge the highway passes over terraces

fronting raised beaches at elevations of 240 and 295 feet (73 and 90 m). A third beach (elevation 200 feet, 61 m) lies just south of the highway. It is interesting that these beaches, particularly the lower beach, stand out as thorium highs in airborne radiometric surveys, apparently the result of monazite-rich strands (B. W. Charbonneau, Geological Survey of Canada, personal communication). A good example of a landslip scar in the Champlain (Leda) clay, is evident just beyond Quyon.

Kirkham Molybdenite Prospect (Locality 9, Figure 4)

Molybdenite was discovered on this property in 1951 and the mining claims were optioned to Quebec Metallurgical Industries Ltd. in the same year. Between 1951 and 1958 the ground was extensively explored for molybdenite and uranium by diamond drilling, trenching, and from two adits. The geology is described by Sabourin (1965, p. 39), Shaw (1958, pp. 23-24) and Vokes (1963, pp. 173-179) and the mineralogy by Sabina (1971, pp. 93-94). The property is located 1.5 miles (2.4 km) east of the Shawville-Otter Lake Road, from where it is accessible by a secondary road at a point 7.7 miles (12.3 km) north of Shawville.

The excursion will visit the No. 1 zone which was explored from the south adit. This zone is a lens of pyroxenite 300 feet (90 m) long and about 20 feet (6 m) thick. The lens lies between a pegmatite sill and a zone of hornblende gneiss and marble, and it extends down dip, at about 45° SE, for at least 200 feet (60 m).

The pyroxenite is medium-to coarse-grained and dark green. It is composed mainly of diopside-hedenbergite but with a little calcite, tremolite-actinolite, microcline, titanite, schorl and local concentrations of coarse (centimetric) scapolite. Some microscopic uraninite is associated with pink calcite. Shaw (1958, p. 24) records "a vein of low density radioactive mineral (probably thucholite)" in the adit.

The sulphides, which tend to occur together in fracture zones, are pyrrhotite, pyrite, molybdenite and very minor chalcopyrite and galena. Locally pyrrhotite makes up the bulk of the rock and occurs in large anhedral grains, some of which have basal parting. Molybdenite is seen as flakes and plates, which rarely show prismatic habit. Flakes up to 3 inches (7.5 cm) in diameter have been recorded by Vokes (1963, p. 178) and Sabina (1971, p. 93). The sulphides have been severely oxidized, producing an abundance

of white rosenite, local yellow jarosite (south end of zone at surface) and rare white tufts of a mineral of the melanterite group.

A 10-foot (3 m) thick pegmatite sill underlies the deposits and was traced, on surface, for 300 feet (90 m). It contains plagioclase, quartz and augite, with lesser amounts of zircon, uraninite, allanite, uranothorite, pyrite and pyrrhotite. Radioactive minerals (up to 1 cm in dimension) can be collected in rock fragments on the dump of No. 1 adit. They are marked by shattering and darkening of the surrounding feldspar.

Yates Uranium Mine (Locality 10, Figure 4)

The Yates uranium mine is 2.7 miles (4.3 km) west of the settlement of Sandy Creek, from where it is accessible by a narrow gravel road. Mica was first mined in 1906 and 1907 from pits on the western side of the property by the Calumet Mica Company of Bryson (de Schmid, 1912, pp. 133-134), and has been mined, intermittently, by other operators since that time.

Allanite was noted from an adjoining lot (de Schmid, 1912, p. 288) but radioactive minerals did not receive attention until the uranium boom of the 1950's. The Yates camp was set up in the fall of 1953 and active exploration continued into the summer of 1956. During this period, six zones known as the Matte, Camp, Cliff, Lake, Belisle and Belanger zones, comprising an area of 835 acres (3.4 km^2), were discovered in eight lots in Huddersfield Township. On this excursion the Matte and Camp zones will be visited.

The Matte zone is a calcite-pyroxene-fluorite-apatite veindyke that cuts granite pegmatite. The zone has been traced on surface for a length of 800 feet (240 m) and a thickness of 20 feet (6 m) and explored by an adit for a length of 170 feet (52 m). It strikes northwesterly and dips about 30° to the southwest. Most of the interesting minerals are located in the hanging-wall side. Calcite is pale to salmon pink; fluorite is the deep purple variety, antozonite; pyroxene occurs as black lustrous prisms of salite, being particularly well-developed at the borders of the zone; and apatite occurs as sharp, doubly terminated green to brown crystals of fluorapatite. Shaw (1958, p. 41) reports apatite crystals up to 10 inches (25 cm) long and three inches (7.6 cm) in diameter but most crystals now available are only 1 inch (2.5 cm) to 3 inches (7.6 cm) in length. Peristerite, scapolite, and microcline also occur with the calcite.

The principal radioactive minerals are uranothorite, which occurs in calcite and fluorite as slender prisms up to 1 inch (2.5 cm) in length, and allanite, which is found in microcline and calcite as plates up to ¾ inch (2 cm) across. Near the end of the adit, uranothorite and allanite coexist in a rock containing about 30% apatite, 50% calcite and 15% thorite (M. Fratta, personal communication). Shaw (1958, p. 41) also reports uranophane and Sabina (1971, p. 96) has identified cerite with stilbite and heulandite in vugs in calcite. A granite pegmatite 400 feet (120 m) southwest of the upper end of the Matte zone contains some coarse allanite.

The Camp zone, 0.7 mile (1 km) southwest of the Matte zone, is an elongated, steeply dipping calc-silicate rock composed mainly of calcite, scapolite, diopside and phlogopite in varying proportions. Radioactivity extends over a length of 900 feet (275 m) and across a maximum width of 100 feet (30 m). The radioactive minerals include thorianite, uranothorite, allanite and uranophane (Shaw, 1958, p. 40). The thorianite occurs as tiny interpenetrating cubes in granular diopside interlayered with salmon pink calcite. A partial analysis of thorianite showed 36.8% U_3O_8, 40.1% ThO_2 and 7.7% PbO (Robinson and Sabina 1955, p. 631, anal. 17). The morphology and petrography of the thorianite were described by Stevenson and Stevenson (1955). Minor lessingite is found in association with the thorianite (Robinson and Sabina, 1955). Lang *et al,* (1962, p. 213) record secondary beta-uranophane. Non-radioactive accessory minerals in the Camp zone include tremolite-actinolite, titanite, chondrodite, fluorite and scapolite, the last having been found as fine crystals up to 2 inches (5 cm) in length.

Bryson Roadcut (Locality 11, Figure 4)

Magnesian marble is exposed in a roadcut about 300 feet (100 m) long on Highway 8, just east of Bryson, Quebec. The area falls within the geological map of Osborne (1944, scale 1:31,680) and the mineralogy of the occurrence has been summarized by Sabina (1971, p. 99). Brucitic marbles in the area have been described by Goudge (1939, pp. 25-28).

Although a number of minerals have been recorded from this occurrence, the rare species hydrotalcite [Mg_6 Al_2 $(OH)_8$ (CO_3) $.4H_2O$], pyroaurite [Mg_6 Fe_2 $(OH)_8$ (CO_3). $4H_2O$] and szajbelyite [Mg (BO_2) (OH)] are of greatest interest. These three minerals may easily be collected from

the northwest end of the outcrop. The following associations are apparent from thin-section studies:

dolomite + calcite + hydrotalcite ± serpentine ± szajbelyite.

dolomite + calcite + pyroaurite + magnetite ± serpentine

Both hydrotalcite and pyroaurite are bluish green, greenish blue or sky blue in hand specimen and brownish in transmitted light. Each mineral occurs as nodules, normally about 1 mm across. At one location, nodules of pyroaurite, 1 cm in diameter, were observed. The minerals are best distinguished by X-ray diffraction, but the association of pyroaurite and magnetite appears to be invariable and diagnostic. Serpentine is commonly associated with these minerals and may be confused in their identification, though it is usually paler and more yellow.

Pyroaurite and hydrotalcite have been observed surrounding brucitic nodules, suggesting their development through the alteration of brucite. Lenses of brucitic marble (dolomite and brucite with little calcite) occur in marble at the southeast end of the occurrence. The heat necessary to generate brucite by dedolomitization, or possibly by decomposing magnesite, could have been derived from the intrusion of a hornblende gabbro, which is found 500 feet (150 m) east of the outcrop.

Szajbelyite (szaibelyite) may be seen as white fibres, about 1 mm long, partly filling cavities in marble. Larger (3 mm) fibres have been collected (A. P. Sabina, personal communication). Boron, essential in the composition of szajbelyite, could have been derived from minor intrusions of a tourmaline-bearing granite pegmatite which cut the gabbro.

Lenses of serpentine marble locally contain abundant small, but well-developed, magnetite dodecahedra.

Other minerals found in this roadcut include: aragonite, chlorite, diopside, galena, graphite, phlogopite, pyrite, pyrrhotite, and titanite.

Chenaux Rapids Dam (Locality 12, Figure 4)

The Chenaux Rapids dam of the Ontario Hydro-Electric Power Commission is on the Ottawa River at Portage-du-Fort, about 50 miles (80 km) upstream from Ottawa. It was completed in 1951 and has a capacity of 120,000 kilowatts. Below the dam an old channelway, deepened in the project, affords an excellent opportunity to view Grenville marble and gabbro. The region has been mapped on a scale

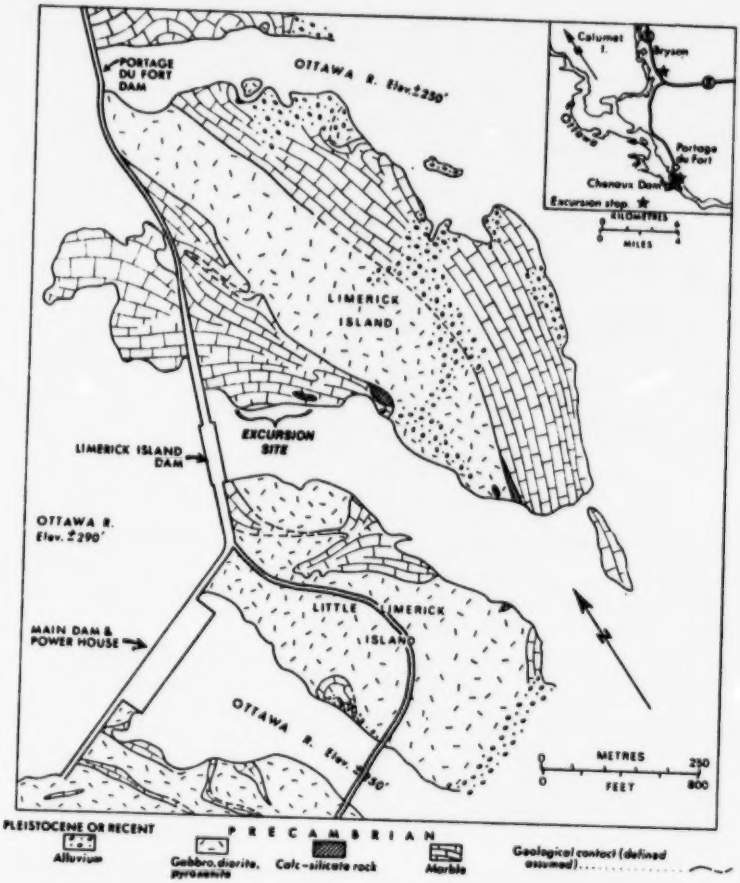


Fig. 9. Geology of the Chenaux Dam Site, Portage-du-Fort, Quebec (after data supplied by J. O. Gorman, Ontario Hydro-electric Power Commission).

of 1:126,720 (1 inch = 2 miles) by Satterly (1945) in Ontario and by Katz (1969) in Quebec. The mineralogy is summarized by Sabina (1971, p. 57).

Marble is exposed, almost continuously, for about 1000 feet (300 m) in the water-cleaned strip at the western edge of Limerick Island in the Ottawa River (Fig. 9). Xenoliths of syenite, granite and gabbro; folds; flowage structures; resistant layers of silicated marble; and small potholes are to be readily seen in the marble. Larger (up to 1 m diameter) potholes may be seen on Limerick Island northwest of the dam. The flowage structures in the marble are particularly evident when viewed from the roadway.

The marble is fine- to medium-grained and normally white, with the calcite carrying diopside and graphite, and more rarely titanite, phlogopite and tremolite. Greenish silicate knots are mainly diopside-scapolite. Grey interlayers contain wollastonite and diopside, some also having vesuvianite, pyrrhotite or feldspar. A greenish rock near the south end of the marble has diopside-garnet-clinozoisite and diopside-scapolite-clinozoisite-calcite associations. Marble at the contact with gabbro has a diopside-garnet-scapolite-calcite assemblage. Near the dam, brownish to greyish lenses of calcite marble enclose dolomite metacrysts containing microscopic grains of spinel and chondrodite. On Little Limerick Island to the west, layers of calcite-dolomite marble contain fresh, purple forsterite crystals up to 1 cm across. Chondrodite-calcite marble occurs at the extreme eastern end of the dam.

Brucitic dolomitic marble is exposed in a roadcut on Limerick Island and is common as boulders near the gabbro. The brucite occurs as nodules averaging less than 1 mm in diameter, commonly surrounded by discrete lamellae of brucite. Some pyroaurite and serpentine are associated with it. In contradistinction from the brucitic marbles near Wakefield, calcite here is rare and spinel is almost entirely lacking.

The marble is cut by plugs of gabbro and by a tongue of gabbro which projects from a small stock on the west side of the Ottawa River. The gabbro normally is a coarse-grained augite-hypersthene variety, but in places grades to diorite or pyroxenite. Locally, lenses of coarse (decimetric) augite and hornblende have been observed. Some joints are coated with golden-brown meionite. A contact with marble

near the south end of Limerick Island contains coarse para-wollastonite poikilitically enclosing diopside.

The silicate assemblage in marble, which is mainly anhydrous, probably results from contact metamorphism by the gabbro intrusions.

MADAWASKA VALLEY AREA

The Madawaska Valley is a broad, northwesterly trending valley drained by the Madawaska River, which interconnects several lakes and joins the Ottawa River at Arnprior, approximately 42 miles (67 km) west of Ottawa. The area was opened up in the middle of the last century for its large stands of timber. To assist the lumbering operations and to hasten (though ineffectively) the settlement of the area, the government built a number of 'colonization roads', the best known being the Opeongo Road, which was constructed in the 1850's. This road, of which vestiges are still to be seen, began at Lac des Chats in the Ottawa River and ran inland to Renfrew and thence to Barry's Bay. A junction road was subsequently constructed to the village of Combermere. Although lumbering continues to be a significant industry, the Madawaska Valley is becoming an important tourist region. A pale-pink nepheline-rich gneiss occurring at the Craigmont mine near Combermere was named congressite in honour of the 12th International Geological Congress held in Canada in 1913 (Barlow, 1915, p. 298).

Apatite-Calcite Vein-Dykes of the Lake Clear Area

In the late 1800's, a great many calcite vein-dykes were explored in the hills just east of Lake Clear, and on islands within the lake. In the course of small-scale mining for apatite, excellent crystals of titanite, zircon, apatite, pyroxene, scapolite, hornblende, and microcline were recovered, many of which found their way into the major mineral collections of the world. Localities for these specimens are variously given as Renfrew, Eganville, Sebastopol, or Lake Clear, Ontario; some with more detail, such as the Smart, or Meany mine, or Turner's Island.

These occurrences are all in Sebastopol Township, Ontario, 6 to 7 miles (9.5 to 11 km) south-southwest of Eganville. The most accessible of the major occurrences are the Smart mine and several on Turner's Island. Lake Clear lies in one of the down-dropped blocks of the Ottawa-Bonnechère horst-and-graben system, and is bounded on the west by the Mount St. Patrick escarpment. Outliers of Palaeo-

zoic sedimentary rocks occur on the top and along the base of the escarpment. A vertical displacement of about 1500 feet (500 m) has been estimated for this fault.

The host rocks of the vein-dykes are variably syenitized biotite gneisses, amphibolites, and 'metamorphic pyroxenites'. All gradations exist from well-foliated gneisses, through localized pegmatite-like patches with or without calcite cores, to well-defined vein-dykes up to several hundred feet (100 m) long and about 10 feet (3 m) wide. Although many of the vein-dykes are more or less conformable with the enclosing gneisses, cross-cutting bodies are common.

All of the minerals listed above, plus biotite, occur as well-formed crystals lining the vein-walls and projecting into the calcite core. Of these, only apatite, zircon, and titanite occur as euhedral, completely isolated crystals within the core. Some of the crystals are up to 3 or 4 feet (1 m) long, and the largest zircons and titanites on record — crystals more than 1 foot (30 cm) in length — were obtained from veins in this area.

Selected references: 46, 47, 74

Smart Apatite Mine (Locality 1, Figure 10)

The Smart mine is reached by a bush road which joins the Eganville-Cormac highway about 6 miles (9.6 km) southwest of Eganville. About 3 miles (5 km) south-southwest of the highway, a foot-path from the bush road leads northeastward to the mine, a distance of 100 yards (90 m). The workings consist of a series of narrow cuts within a length of about 100 yards (90 m), exposing a group of both conformable and cross-cutting, steeply-dipping vein-dykes.

Most of the above-noted vein minerals have been found here, but large, well-formed crystals of microcline-perthite are particularly conspicuous in present exposures. Thin seams of crocidolite are common and were apparently developed during relatively late shearing.

Turner's Island, Apatite Mine (Locality 2, Figure 10)

Turner's Island is an elongate island in Lake Clear, about 3 miles (5 km) south-southeast of the resort settlement along the north shore of the lake, and is readily accessible

Fig. 10. Mineral localities, Madawaska Valley area, Ontario.
1—Smart apatite mine, 2—Turner's Island apatite mines, Lake Clear, 3—Quadeville beryl-lyndochite pegmatite, 4—Rosenthal corundum occurrences, 5—Craigmont corundum mine, 6—Gole feldspar quarry. (Opposite page).

Miles
Kilometres
Lake Clear
Golden Lake
Round Lake
Killaloe Station
Haley Station
Douglas
Calabogie
Palmer Rapids
Quadeville
Renfrew
Eganville
Barry's Bay
Wilno
Combermere
Madawaska
Mississippi R.
Ottawa R.
Bonnechere R.
Opeongo Lake
Algonquin Park
Whitney
Dwight
Huntsville
Bracebridge
Gravenhurst
Muskoka Lakes
Parry Sound
Pembroke
Deep River
Chalk River
Petawawa
Arnprior
Carleton Place
Almonte
Perth
Smiths Falls
Brockville
Prescott
Cornwall
Hawkesbury
Lachute
Montreal
Ste. Agathe
St. Jerovme
Ste. Adele
Ste. Sauveur
Mont Tremblant
Lac Ste. Marie
Lac Des Seize Iles
Lac Des Deux Montagnes
Ste. Anne
Vaudreuil
Hudson
Ste. Scholastique
Ste. Therese
Ste. Rose
Ste. Dorothee
Laval
Montreal
Lachine
Ste. Anne de Bellevue
Ste. Anne de Bellevue
Ste. Anne de Bellevue

from these settlements by boat. It is about ½ mile (800 m) offshore from the southern terminus of the bush road which passes the Smart mine.

At various places on Turner's Island, more than ten vein-dykes have been worked on a small scale for apatite. The largest and most accessible workings are in the northeastern portion of the island. Some of the vein-dykes are exposed in the cliff which forms the north shore of the island. All vein minerals noted in the general description of the Lake Clear occurrences have been found in vein-dykes on Turner's Island.

Quadeville Beryl-Lyndochite Pegmatite (Locality 3, Figure 10)

Lyndochite was first described from a granite pegmatite which was operated on a small commercial scale for beryl in Lyndoch Township, Ontario. The dyke was opened up in 1926, but most development work was done from 1935 to 1949. The property is now privately-owned by Wal-Gem Mines and Minerals, Quadeville. The occurrence is reached by a short access road leading off the Quadeville road at a point 1. 2 miles (2 km) north of Quadeville.

The geology of the occurrence is described by Hewitt (1954) and Rose (1960). The pegmatite dyke strikes N 56° E and dips about 15-20°NW, cutting sharply through a band of hornblende-biotite gneiss and gneissic granite. It is sinuous and irregular in width, and varies in texture and composition, including in places fragments or xenoliths of the country rock. The dyke has been exposed by an open cut approximately 250 feet (76 m) long and 50 feet (15 m) wide, and from 6 to 35 feet (2 to 11 m) deep. A plan of the present workings is shown in Figure 11. A central constriction of the dyke divides it into two parts, a western part that is zoned and coarse-grained and an eastern part that is largely undifferentiated and relatively fine-grained. The zoned part has a quartz core, an intermediate zone of microcline-perthite, and a wall zone of medium to coarse-grained albite-quartz-microcline-perthite. These are cut by later zones of quartz-tourmaline-cleavelandite. The eastern portion is essentially a micro-pegmatite composed of pink albite, microcline, quartz and biotite, sheathed by a four foot (1.2 m) thick zone of coarse albite, quartz and microcline-perthite.

Lyndochite was first recorded from this dyke by Miller (1898) as an unknown columbate, and was later described and named by Ellsworth (1927). Ellsworth found it to have

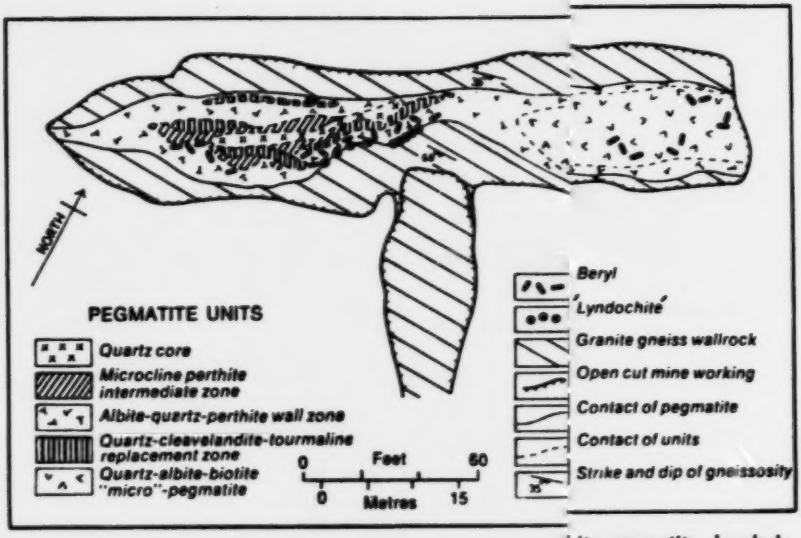


Fig. 11. Geological map of the Quadeville beryl-lyndo hite pegmatite, Lyndoch township, Ontario [after Hewitt (1954)].

a morphological resemblance to euxenite b ut believed that compositional differences were sufficient to justify a distinc- tive name, lyndochite being relatively low in uranium and high in niobium, calcium and thorium. Its status as a dis- tinct species still appears uncertain. Anal yses of the type material are reported by Ellsworth (op. cit.) and Butler (1957). Butler found that lyndochite chem ically resembles aeschynite rather than members of the e uxenite-polycrase group, and Horne and Butler (1965) found it and a 'lyndo- chite' from Kenya to yield similar X-ray di fraction patterns after heating, distinctive from patterns o btained for any other metamict mineral. Fleischer (1966) t entatively classes the mineral as thorian neodymian aeschyn te.

Lyndochite at Quadeville occurs as thick prismatic crys- tals up to about two inches (5 cm) in leng th, commonly as- sociated with magnetite and allanite. The mineral is dull on external faces but brilliant black on fr sh surfaces, and has a conchoidal fracture. The beryl is pale-bluish and occurs in crystals 1 to 4 inches (2.5-10.2 cm) in diameter, though crystals up to eight inches (20 cm) in diameter and three feet (0.9 m) in length are recor ed. Terminated

crystals are uncommon. Although rare, some faceting-quality aquamarine has been collected. Magnetite occurs as crystals and small masses in the pegmatite, and as small metacrysts in the biotite gneiss. These metacrysts are marked by light-coloured biotite-free halos. Columbite occurs as thin, flat masses, commonly disc-shaped with concentric markings, on cleavages or partings of feldspar. Other accessory minerals reported are tourmaline, garnet, cyrtolite, allanite, fluorite, apatite, monazite and strüverite. Interesting feldspars include amazonite, cleavelandite and peristerite, the last exhibiting an excellent play of colours.

Rosenthal Corundum Occurrences (Locality 4, Figure 10)

Corundum was mined on a small scale from several occurrences in the vicinity of Rosenthal, near the common corners of Brudenell, Radcliffe and Raglan Townships, 7 miles (12 km) due east of Combermere, Ontario. In this area corundum-and nepheline-bearing rocks form part of a single sheet-like body of alkaline gneisses that is interlayered with variably syenitized and granitized gneisses and marble. The overall structure is nearly horizontal but because small undulating folds are superimposed upon it, the favourable zone shows five repetitions of outcrop across a distance of about 6000 feet (1800 m).

The corundum and nepheline rocks and their structural relationships are well shown in the fields in the southern part of the Gutz farm, just east of the Brudenell-Rockingham Road and north of its intersection with the Brudenell IV-V Concession Road (about ½ mile, 800 m north of the Rosenthal intersection). Here, the sheet of alkaline gneisses forms a gently southward-plunging syncline with a core of variably syenitized dark gneisses. On the slope just south of the Gutz farmhouse, nepheline-rich gneisses of the west limb are well exposed. These contain elongate, tapered crystals of brown corundum up to eight inches (20 cm) long, showing a bronzy schiller on the basal plane. Southward along strike, the nepheline-rich gneisses are intruded by granitic pegmatites and altered to masses of feldspar-rich rock containing stocky, grey to brown crystals of corundum, as shown in the exposures in the small open-cut.

Just south of the concession-line road, and in the trough of the syncline, another small open-cut exposes more of the feldspar-rich corundum rocks cut by granitic pegmatites, some of which are allanite-bearing.

Selected references: 4, 10, 23, 27, 55, 67.

Craigmont Corundum Mine (Locality 5, Figure 10)

Corundum was mined from many workings on the south slope of Craig Mountain in Raglan Township, about 4.5 miles (7 km) south of Combermere, Ontario. This mine was probably the world's largest single source of grain corundum, having produced 20,000 tons from 1900 to 1913. Another 2000 tons was recovered by re-milling old tailings in the mid-1940's. A town of more than 2000 people was established on the adjacent sand-plain during the major period of operations, although little evidence remains of the community.

Open-pit workings extend for more than a mile (1.6 km) across the south slope of the mountain (Fig. 12). The main workings, near the eastern end, consist of twenty open cuts, extending from the base to the top of the slope, a vertical distance of about 500 feet (150 m). An exploration adit was driven into the hillside at the base of the slope. Ten open pit workings, known as the Klondike Cuts, are relatively high up on the western portion of the slope.

The corundum-bearing zone, which is sheet-like and up to about 200 feet (60 m) thick, consists of a series of interlayered and interfingered alkaline gneisses. These range widely in composition, and include nepheline-rich, scapolite-rich, plagioclase-rich (oligoclase to andesine) and microcline-rich types, many of which contain corundum. The corundum-bearing zone is underlain by a thick series of granitized amphibolites, and is overlain by several hundred feet (about 100 m) of partially syenitized or granitized amphibolites, above which is coarsely crystalline marble. All of these have been correlated with the Grenville Group. The rocks dip moderately southward and the dip-slope reflects the differential erosion of the overlying marble. Minor folds and flexures superimposed on the major south-dipping structure have produced undulations in the sheet-like corundum-bearing zone. Thus, at some places, this favourable zone is truncated by the present erosion surface, but elsewhere it is still deeply buried. The open-cut workings were started on outcroppings of corundum-bearing rocks and followed them down to the limits of economic mining, so that some corundum can be observed in most of the exposed faces.

The alkaline gneisses were probably formed by the reaction of alkali- and alumina-rich hydrothermal solutions on pre-existing gneisses, and subsequently were themselves attacked and altered during granitization of the underlying gneisses, and later, on direct intrusion of granitic and syen-

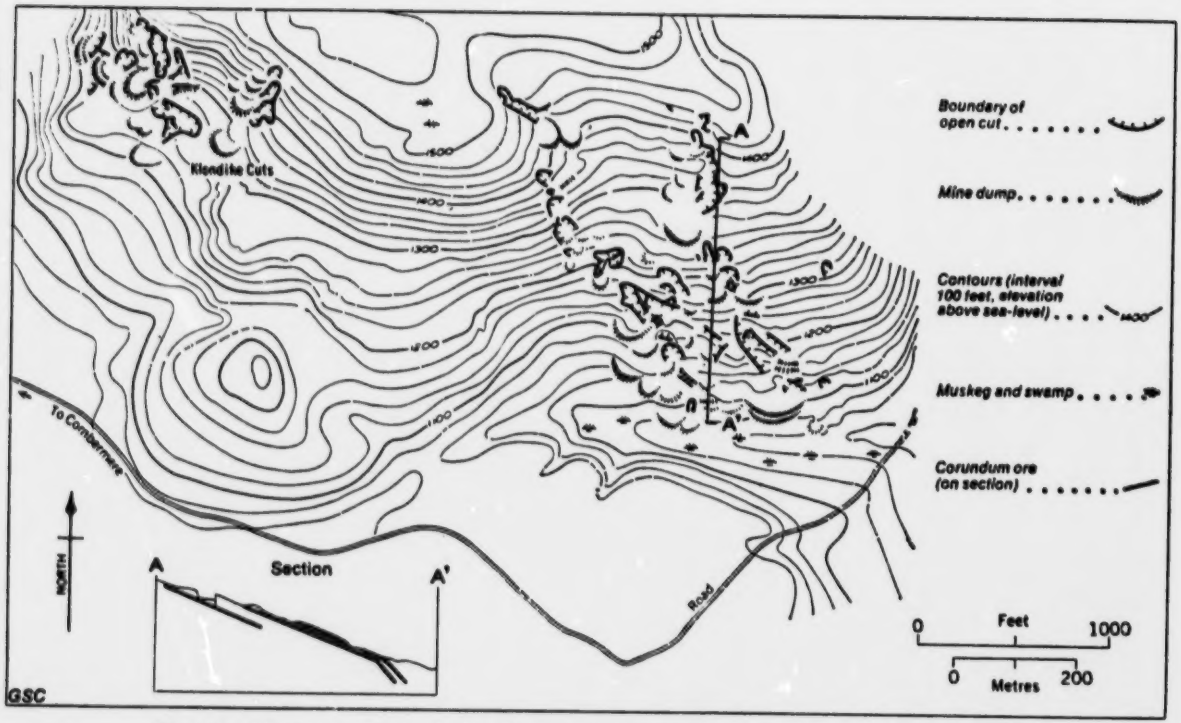


Fig. 12. Plan and section of the Craigmont corundum mine, Raglan township, Ontario.

itic pegmatites. Nepheline-rich gneisses were locally converted to masses of coarsely crystalline microcline with well-formed crystals of corundum. These are the "corundum-syenite pegmatites" of the earlier literature, and were the principal source of the corundum mined. Nepheline-bearing gneisses do not crop out in the main workings but are well exposed in the adit and in the Klondike Cuts.

The corundum throughout most of the deposit occurs as irregular grains or stocky hexagonal prisms up to 1 foot (30 cm) in length. In the nepheline-rich rocks, it occurs as elongate tapered prisms, usually separated from the nepheline by a narrow selvage of soda-feldspar. Most of the corundum is brown, but some ranges from nearly colourless, through translucent yellows and greens. Colour-zoning is common. All of the corundum shows well-developed rhombohedral and basal parting, and much of it shows a bronzy schiller on the basal plane. Most corundum crystals and grains have alteration-rims of muscovite. Well formed crystals of many other minerals have been found, including microcline, plagioclase, scapolite, biotite, muscovite (including curved and zoned crystals), quartz, calcite, apatite, magnetite, titanite, tourmaline, garnet, allanite and chabazite. Other minerals which have been collected include zoisite, molybdenite, hematite, pyrite, ankerite, hornblende, aegirine-augite, epidote, chlorite, anhydrite, gypsum and natrolite. Gieseckite and hydronephelite are widespread alteration products.

Selected references: 1, 2, 4, 8, 10, 23, 27, 55, 56, 67.

Gole Feldspar Quarry (Locality 6, Figure 10)

The Gole quarry was operated for feldspar from 1941 to 1944 by J. G. Gole and later by D. L. Ross and Company, the total production being approximately 10,000 tons. Several thousand tons of quartz were also recovered. Fergusonite was recognized in the quarry by L. Moyd in 1941, and specimens have since become widely distributed.

The quarry is developed on a pegmatite on the south slope of a low hill in Murchison Township, Ontario, near the town of Madawaska, a former railway divisional point which flourished in the days of the steam engine. Access is provided by a narrow road approximately one-quarter mile (0.4 km) long which joins a secondary road 2 miles (3.2 km) from the junction of this secondary road with the main highway to Madawaska. The main quarry is an open cut approximately 500 feet (150 m) long, 30 feet (9 m)

wide and 10 to 30 feet (3 to 9 m) deep. The southern half of this cut is overgrown and generally water-filled, and accessibility to it is therefore limited. A smaller cut about 70 feet (21 m) long and 15 feet (4.5 m) wide is to the northwest.

The pegmatite dyke strikes N 30°E and cuts hornblende-biotite gneiss. The dyke dips vertically, or nearly so, and is 30 to 40 feet (9 to 12 m) wide. From present exposures and accounts it appears to have been a zoned pegmatite with a quartz core, an intermediate zone of very coarsely crystalline quartz and feldspar, and a wall zone of predominantly plagioclase with segregations of biotite and accessory radioactive minerals. Casts of feldspar crystals up to 20 feet (6 m) in length are recorded by Satterly (1945), one crystal is reported to have supplied 300 tons of feldspar.

Fergusonite, associated with cyrtolite, occurs in radial masses of biotite exposed on the northwest face of the main working, normally embedded in quartz or feldspar that is interlayered with the biotite sheets. The fergusonite typically occurs as brownish black crystals having long, tapered, tetragonal dipyramids and prominent pinacoidal terminations. These range up to 3 inches (7.5 cm) in length and ¾ inch (2 cm) in width. Accessory minerals include allanite, magnetite and uraninite. Allanite crystals and casts up to two feet (0.6 m) in length and six inches (15 cm) in thickness may be seen in the quarry wall. Pink peristerite and greyish pink sunstone suitable for lapidary purposes are recorded by Sabina (1971).

BANCROFT AREA

Bancroft is located on the junction of the old Hastings, Monck and Mississippi colonization roads. The village was settled in 1853 and, because of is strategic location, was for a long period an important lumbering centre. The Bancroft area has become world-renowned for its large variety of minerals, for its unique uranium deposits, and for its nepheline-rich rocks. These have been studied by a succession of workers, including Adams, Barlow, Ellsworth, Gittins, Hewitt, Satterly, Tilley and many others, and no doubt will continue to hold the attention of mineralogists and petrologists. In the 1950's uranium deposits of the pegmatitic class in the Bancroft area were the first to be developed on a commercial scale. The village today is an important resort and tourist centre. A mineral show, the Bancroft Gemboree,

Fig. 13. Mineral localities, Bancroft area, Ontario.
1—Princess sodalite mine, 2—Cancrinite Hill, 3—Davis Hill nepheline veindykes, 4—Goulding-Keene nepheline pegmatite quarry, 5—Egan Chute corundum prospect, 6—York River tactite zone, 7—MacDonald feldspar mine.

is held annually and attracts many thousands of 'rock-hounds'.

Princess Sodalite Mine (Locality 1, Figure 13)

The Princess open-cut mine has been worked sporadically on a small scale since 1906 for blue sodalite for architectural and lapidary purposes. The workings are on a small hill just north of the East Road, in Dungannon Township, about 2.5 miles (4 km) northeast of Bancroft.

This deposit and several other well-known mineral localities occur within a series of alkaline gneisses that extend for about 4 miles (6.5 km) eastward from Bancroft. These rocks, many of which are nepheline-rich, are interlayered with marble and variably syenitized and granitized paragneisses and are correlated with the Grenville Group. The rocks dip to the southeast and may represent an overturned, northeastward-plunging syncline, with nepheline-rich gneisses on both limbs, and nepheline-poor to nepheline-free gneisses in the core. If this interpretation of structure is correct, the Princess mine lies on the north limb, and the Cancrinite Hill and Davis Hill occurrences on the south limb of the syncline. Minor folds have been superimposed on the general structure.

The major minerals of the nepheline-rich gneisses are nepheline, alkali-feldspars, biotite, magnetite, and calcite. Locally, these gneisses have been recrystallized to coarsely crystalline, pegmatite-like patches, but with little or no change in composition. At the Princess mine, and on a lesser scale at various other places in the nepheline-corundum belt, some of the nepheline-rich gneisses and pegmatitic patches have been replaced by sodalite, ranging from filaments and narrow stringers to nearly pure masses up to 4 feet (120 cm) in diameter. Individual cleavages of sodalite may reach a width of 4 inches (10 cm). Minerals associated with the sodalite-rich masses include nepheline, alkali feldspars, biotite, magnetite, calcite, pyrite, and pyrrhotite. Some sodalite-bearing zones appear to be spatially related to joints or fractures. There are many granitic to syenitic dykes in the area, including some small ones within the workings. These intrusives may have been responsible for the circulation of hydrothermal solutions through the joint systems, converting nepheline to sodalite. Radial aggregates of natrolite occur along joints and represent a later, lower-temperature stage of alteration.

The nepheline-rich gneisses here are cut by several calcite-cored vein-dykes which are lined with crystals of nepheline, alkali feldspar, biotite, magnetite, and apatite. These vein-dykes are similar to the ones on the Davis Hill and were probably formed prior to the sodalite mineralization, since some of the nepheline crystals have been partially replaced by sodalite.

The rocks of the area have been mylonitized by late movement, the sodalite-rich mylonite being particularly attractive.

Selected references: 1, 2, 27, 29, 55, 83.

Cancrinite Hill (Locality 2, Figure 13)

Sporadic operations on a very small scale have recovered yellow-orange cancrinite and blue sodalite as specimens and lapidary materials from showings on the Cancrinite Hill in Dungannon Township. The occurrence is on the steep west face of the hill, ½ mile (800 m) south of the Princess sodalite mine, and about 2.5 miles (4 km) east-northeast of Bancroft. The showings are reached by foot-trails from the East Road.

The hill consists of nepheline-rich gneisses forming the south limb of a postulated northeastward-plunging overturned syncline. Locally, pegmatitic patches have developed through recrystallization of the gneisses. Some calcite-cored vein-dykes are also present.

At several places, the nepheline of the gneisses, pegmatitic patches and veins has been partially replaced by cancrinite and sodalite. In some cases, cancrinite and sodalite have replaced the feldspars as well as the nepheline of the gneisses, but biotite and magnetite remain relatively unaffected and still mark the original gneissic foliation. Other minerals which occur in the cancrinite and sodalite zones include tourmaline, molybdenite, zircon, and monazite.

Many granitic to syenitic dykes intrude the alkaline gneisses. A low-dipping syenite dyke about 10 feet (3 m) thick immediately underlies this occurrence and might have been the source of hydrothermal solutions which react with the nepheline-rich rocks to form the cancrinite and sodalite.

Selected references: 1, 27, 29, 55, 83.

Davis Hill Nepheline Vein-Dykes (Locality 3, Figure 13)

Large, well-formed crystals of nepheline and biotite occur in an old mica prospect on a shoulder of the Davis Hill,

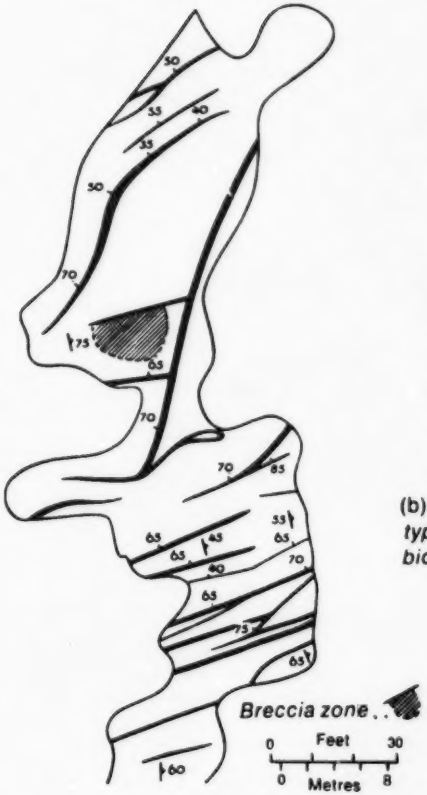
The occurrence is about 2000 feet (600 m) south-southeast of the Princess sodalite mine, and is also in Dungannon Township. It is about 2.5 miles (4 km) east-northeast of Bancroft, and is accessible by foot-trails from the East Road. In the early 1900's, some stripping and test-pitting was done in an abortive attempt to produce mica. In 1966, the National Museum of Canada conducted a small-scale mining operation for the recovery of mineral specimens.

The nepheline-rich gneisses of the Cancrinite Hill continue through the Davis Hill, where diamond-drilling has shown an average content of about 24 per cent alumina, i.e. about 50 per cent nepheline. Although the Davis Hill gneisses form part of the south limb of a postulated northeastward-plunging syncline, they strike northward because of a small fold superimposed on the general structure. A well-developed eastward-trending joint-system transects the gneissic structure (Figure 14).

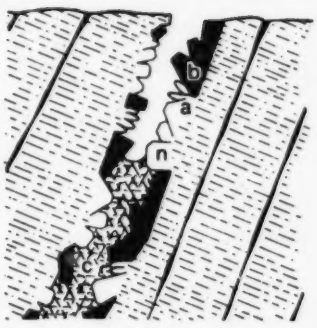
Calcite-cored vein-dykes lined with well-formed crystals of nepheline, biotite, and antiperthite, have developed along some of these tension joints. The veins range from less than a foot (30 cm) to more than 100 feet (30 m) in length, and from a fraction of an inch (less than 1 cm) to more than 3 feet (1 m) in thickness.

Pinching and swelling is common, and many bodies are pod-like. Most of the veins dip moderately to steeply northward. Some are less steep, and may curve in both plan and section, crossing or coalescing with others. Brecciated zones in the gneisses contain pockets of similar vein-material. The major minerals of the vein-dykes are the same as those of the enclosing gneisses, i.e. nepheline, alkali-feldspar, iron-rich biotite, and calcite. Nepheline occurs as translucent, light-grey, equidimensional crystals up to two feet (60 cm) long. These show varied degrees of development of the hexagonal prism, dipyramid, and base. Biotite (lepidomelane) occurs as splendent, black, prismatic-to-tapered crystals up to 2 feet (60 cm) long. Antiperthite occurs as translucent, grey-to-tan tapered crystals up to 4 inches (10 cm) long. The calcite in the cores is coarsely crystalline and shows pressure-induced rhombohedral parting. Minor vein-constituents include crystals of apatite, tourmaline, and zircon, and irregular masses of magnetite, pyrite, and pyrrhotite.

The structure and composition of the veins and their gradational contacts suggest that the veins were formed from wall-rock minerals that had been recrystallized under



(a) *Plan of stripped outcrop showing vein-dykes in nepheline gneiss*



(b) *Idealized section of vein showing typical development of nepheline (n), biotite(b), antiperthite (a), calcite (c)*

Fig. 14. Nepheline-bearing vein-dykes, Davis Hill, Bancroft, Ontario.

the influence of hydrothermal solutions. The nepheline-rich gneisses of the area have been intruded by many granitic to syenitic dykes, some of which crop out immediately north of the stripping. Intrusion of these bodies may have been related to the dilation of the joint-systems. The intrusions, themselves, might have been the sources, or at least have afforded the energy for the circulation of the hydrothermal solutions which reacted with the wall-rock gneisses to produce the veins, and also, as temperatures dropped, some of the later alteration products.

In both the gneisses and the veins, sodalite and cancrinite occur as relatively high-temperature alteration products. Many of the nepheline crystals have been partially replaced by sodalite. Natrolite, hydronephelite, and vermiculite are common lower-temperature alteration products.

Some veins have been affected by regional stresses, causing flowage of the calcite, bending and cleavage-plane slippage of the biotite, and fracturing of the nepheline crystals.

Near the surface, much of the calcite has been leached away, leaving fissures which are now filled with boulders, sand, clay, soil, and humus, affording excellent rooting for trees and shrubs.

Selected references: 55, 83.

Goulding-Keene Nepheline Pegmatite Quarry (Locality 4, Figure 13)

The Goulding-Keene quarry represents one of the unsuccessful attempts in the late 1930's to produce ceramic-grade 'nepheline syenite' concentrates from the nepheline pegmatites.

The quarry is on the west bank of the York River, about ¼ mile (400 m) north of the East Road bridge, and accessible via a spur from the East Road. It is in Dungannon Township, Ontario, about 6 miles (10 km) east of Bancroft.

The quarry is near the southern end of the eastward-dipping York River series of alkaline gneisses, a narrow belt which has been traced northward for about 6 miles (10 km). A major fault forms the southern terminus. These alkaline gneisses vary greatly in composition, ranging from nepheline-rich members near the top, through pyroxene- and amphibole-rich members in the middle, to feldspar- and biotite-rich members with some corundum, near the base. One 60-foot (18 m) thick nepheline-rich zone (with minor garnet and hastingsite) averages more than 30 per cent alumina,

and thus more than 80 per cent nepheline. Nepheline-rich gneisses are well exposed immediately south of the quarry, the proportion of nepheline being readily apparent on weathered surfaces. In this area, the alkaline gneiss series is about 500 feet (150 m) thick, and is both overlain and underlain by marbles; a few thin beds of marble are intercalated with the gneisses. The alkaline gneisses grade into the immediately underlying calcareous metasediments and the series as a whole may represent various types of calcareous sediments which have been nephelinized. The pyroxene (ferrosalite) and amphibole (hastingsite) gneisses have been considered to be nephelinized skarns.

In the upper portion of the series, numerous coarsely crystallized, pegmatite-like masses have been developed through recrystallization of nepheline-bearing gneisses, and some appear to have been localized along crests of drag-folds. The principal constituents of the pegmatitic masses are almost the same as those of the adjacent parent gneisses — nepheline, albite-oligoclase and calcite — but the dark mineral is almost universally biotite (lepidomelane). The gradation of nepheline-plagioclase-biotite gneiss into coarsely crystallized, massive rock with the same mineral constituents is well shown in the outcrop just above the west face of the quarry.

Individual crystals of nepheline and plagioclase may exceed 6 feet (2 m), and crystals of biotite, 1 foot (30 cm) in diameter. Large crystals of these minerals are exposed in the walls of the quarry. Much of the plagioclase shows a delicate play of colour. Accessory minerals in this quarry include cyrtolite, apatite, graphite, sodalite, cancrinite, natrolite, hydronephelite, and gieseckite. In some of the other pegmatitic bodies in this belt, tourmaline, muscovite, uranothorianite, allanite, pyrite, pyrrhotite, molybdenite, and galena have also been found.

Selected references: 1, 2, 22, 27, 29, 55, 83.

Egan Chute Corundum Prospect (Locality 5, Figure 13)

The Egan Chute is a waterfall in the York River about 1500 feet (450 m) north of the Goulding-Keene quarry, and is reached from the quarry by a foot-path along the west bank of the river. Minor exploration and some intensive mineral-specimen collecting have been done on a corundum-bearing zone which is crossed by the path, about 600 feet (180 m) south of the Chute.

The Egan Chute marks the base of the York River series of alkaline gneisses. Between the corundum zone and the Chute the alkaline gneisses grade downward, across strike, into calcareous metasediments. During periods of low water, this gradation is exposed in continuous outcrop.

The corundum showing is a tabular, eastward-dipping, 5-foot (1.5 m) thick body of plagioclase-nepheline-corundum-muscovite-biotite gneiss. It can be traced southward for at least 200 feet (60 m) but northward appears to lens out at the river-edge. A bulk sample taken near the trail contained 14 per cent corundum, but the corundum content of most exposures appears to be appreciably lower. The corundum occurs as translucent, somewhat milky, grey to light-blue (rarely dark-blue) tapered hexagonal crystals. All show basal and rhombohedral parting. Most of the corundum is rimmed by muscovite, and some granular aggregates of muscovite may represent corundum that has been completely replaced. Galena is thinly disseminated throughout the rock, and most of the nepheline has been altered to hydro-nephelite.

The calcareous gneisses exposed in the Chute and adjacent cliffs show strongly developed flowage structures. A large eye exposed in the Chute consists principally of diopside and scapolite, with pockets of calcite lined by inward-projecting crystals of diopside, scapolite, actinolite and feldspar. The rocks of the sheer cliff on the east bank are complexly drag-folded, possibly because of the buttress-effect of a small plug of Precambrian gabbro immediately to the northeast.

Selected references: 1, 4, 27, 29, 55, 83.

York River Tactite Zone (Locality 6, Figure 13)

Mineral specimens have been collected intensively from the cliff on the east bank of the York River, directly opposite the Goulding-Keene quarry. The occurrence is reached from the East Road by a truck-road along the east bank of the river.

A medium- to high-temperature metamorphic suite has been developed in dolomitic marbles which overlie the York River series of alkaline gneisses. The reaction products range from tough, granular aggregates to isolated euhedral crystals. Crystals of the following have been collected: essonite, diopside, vesuvianite, zircon, spinel, olivine, and chlorite. Other minerals include cancrinite in the form of colourless cleavage-masses, blue calcite, plagioclase, scapolite, chondrodite, pyrrhotite, graphite, brucite and some of its fine-grained alteration products.

This wide-ranging suite of metamorphic minerals reflects the complex history of the occurrence, which would appear to include the following sequence of events:

1) Regional metamorphism of impure dolomitic limestones.
2) Contact metamorphism on emplacement of the extensive body of metagabbro which crops out just to the east.
3) Infusion of alkaline and aluminous hydrothermal solutions during the nephelinization of the underlying York River series.
4) Infusion of hydrothermal solutions, somewhat 'filtered' through the alkaline gneiss series, on emplacement of the granitic body which crops out a short distance to the west. (A narrow dyke of granitic pegmatite cuts a layer of dark amphibolite at the base of the cliff).

Lastly, the marbles and their reaction products have been deformed by flowage and mylonization.

Selected references: 1, 29.

MacDonald Feldspar Mine (Locality 7, Figure 13)

The MacDonald mine was the largest producer of feldspar in the Bancroft district. The mine is located on the southeastern slope of a drift-covered hill in Monteagle Township, Ontario and is approximately 4 miles (6.4 km) by road east from Highway 62, at a turn-off point 6.2 miles (10 km) north of Bancroft. The main workings, which will be visited, are shown in Figure 15. Three smaller cuts are to the west. The mine, leased from one Peter MacDonald, was opened up in 1919 by the Pennsylvania Feldspar Company and operated under several ownerships until 1935, producing some 35,000 tons of feldspar. In the mid 1950's the mine was explored as a source of radioactive minerals. This included some drifting and cross-cutting in the main working.

The main dyke strikes east-west and dips 60-70°N, cutting a complex assemblage of paragneiss, amphibolite, silicated marbles and granitic and syenitic gneisses. The dyke is roughly lens-shaped and up to 70 feet (21 m) wide at its central portion. It pinches out to the west. The dyke was mined initially by open-cutting and benching along strike into the hillside, and later by drifting and stoping at a lower level. The open cut is approximately 550 feet (168 m) long, 70 feet (21 m) wide and 120 feet (37 m) deep. Stoping up dip from the lower level has created a large open

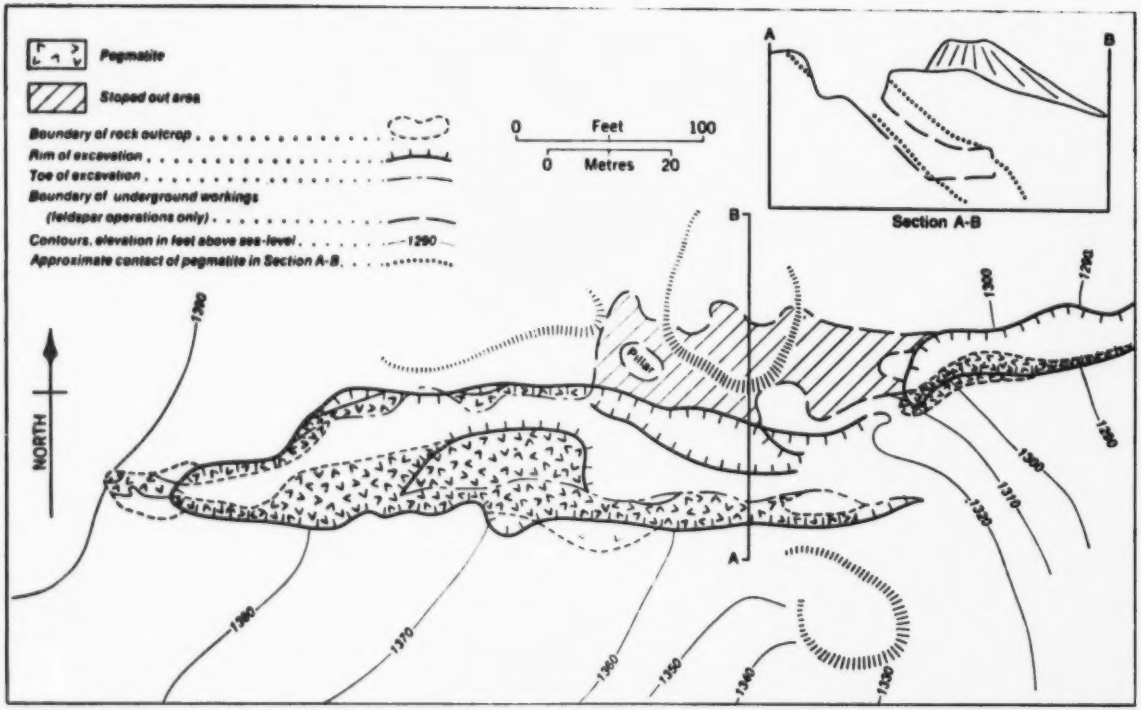


Fig. 15. Plan and section of main workings, MacDonald mine, Monteagle township, Ontario [after Hewitt (1955)].

stope connecting the two levels, in which a vertical section of the dyke has been exposed.

Descriptions of the mine are given by Ellsworth (1932) Hewitt (1955) and Satterly (1957), and the following has been summarized from their accounts. The main dyke is a zoned pegmatite consisting of a central core of massive quartz; an intermediate zone of coarsely crystalline quartz and microcline-perthite; a wall zone of medium-grained albite- microcline-quartz pegmatite; and a border zone of fine-grained graphic granite. Crystallization was on a large scale with quartz masses up to 30 feet (9 m) across and feldspar crystals up to 15 feet (5 m) in length. Ellsworth records crystals of pyroxene and allanite up to a foot (30 cm) or more in dimension. Large crystals of feldspar and allanite may be observed in the open stope. Coarse-grained white to salmon coloured calcite appeared in a few places, mixed with quartz in masses up to 100 tons in weight. Ellsworth considered the calcite to be "as much a primary constituent in the dyke as the quartz and feldspar".

The MacDonald mine is best known for its radioactive minerals, notably ellsworthite and cyrtolite. Ellsworthite, named in honour of H. V. Ellsworth of the Geological Survey of Canada, is a niobium-tantalum oxide containing appreciable U_3O_8 (to 19.2 per cent) and H_2O (to 12.8 per cent). Two complete analyses are given by Ellsworth (op. cit.) and three partial analyses by Hogarth (1959). The mineral is generally listed as a uranian pyrochlore, but Hogarth (1959) considers it to be a variety of betafite owing to its high content of uranium (>15%). The mineral typically occurs as yellow and brown-to-black masses, commonly in salmon calcite. It is brittle and without cleavage. Cyrtolite, a variety of zircon rich in hafnium, occurs as individual crystals, or as aggregates of crystals, with curved faces. Uranothorite (46.33 per cent ThO_2, 17.26 per cent U_3O_8) is recorded by Ellsworth as black, elongated square prisms up to ½ inch (1.3 cm) in cross-section, and its identification at the mine was the first to be reported in Canada. White and yellow-brown films coating uranothorite crystals were named alpha-hyblite and beta-hyblite, respectively, by Ellsworth, who regarded them as basic sulpho-silicates of, chiefly, thorium. Recent work on type material indicates the white material to be anglesite and the yellow-brown material to be probably thorogummite. Other minerals recorded from the dyke include scapolite, pyrrhotite, dark purple fluorite, pyrite, zircon, magnetite, ilmenite, and minor chalcopyrite and galena.

Allanite, ellsworthite and cyrtolite all give rise to a radial fracturing of their enclosing feldspar and quartz, which may be observed in the walls and back of the open stope.

WILBERFORCE AREA

The village of Wilberforce is 18 miles (29 km) west of Bancroft and is the centre of a thriving tourist community. The Wilberforce area is notable for a number of mineral localities, including occurrences of radioactive minerals, the first of which was the discovery in 1922 of the Fission (Richardson) property. This, and two other radioactive mineral occurrences, will be visited on the excursion.

Silver Crater (Basin) Mica and Betafite Mine (Locality 1, Figure 16)

The Silver Crater mine is in Faraday Township, Ontario, 8 miles (13 km) south-southwest of Bancroft. It is reached by a 1¼ mile (2 km) access road which goes north from the Monck Road about 2 miles (3 km) northeast of Cardiff townsite. Between 1927 and 1951, biotite sheet and scrap mica were produced intermittently from a large calcite vein-dyke. From 1953 to 1955, the vein-dyke was explored for betafite.

The biotite was mined from an open-cut driven into the east slope of a hill. The lower part of this cut is now filled with water. Betafite was originally discovered as loose crystals in the residual soil derived from the out-cropping calcite body. Exploration for betafite included trenching, pitting, and stripping on a shoulder of the hill, then more than 5000 feet (1500 m) of diamond-drilling. An adit was driven northward into the hillside, with several ramifying drifts and cross-cuts at adit-level, and a raise into the stripped area.

The country-rocks are biotite-amphibolites which are enclosed in variably syenitized gneisses, including nepheline-bearing and other alkaline gneisses (a westward extension of the Bancroft belt). These are underlain by granitized gneisses and overlain by marble. The deposit lies immediately west of the axis of a southward-plunging syncline.

The lenticular body of coarsely granular calcite is at least 400 feet (120 m) long, and averages about 50 feet (15 m) in thickness. The body strikes about N15°W and dips 10° to 40° eastward. It is more or less conformable with the foliation of the enclosing amphibolite, but there is great irregularity and interfingering along contacts.

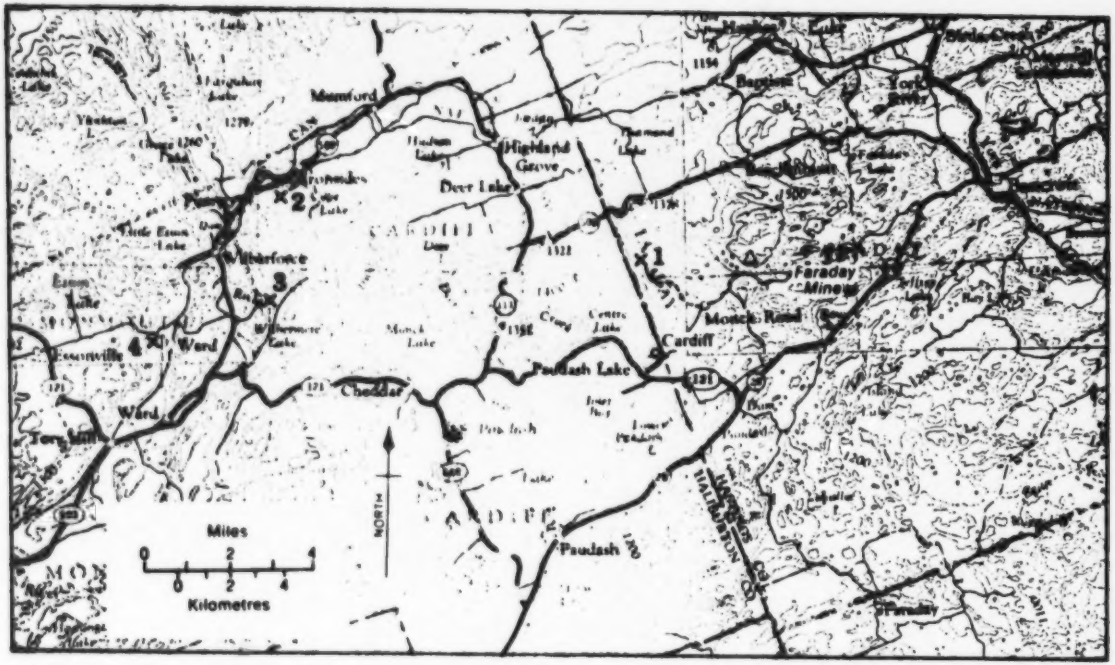


Fig. 16. Mineral localities, Wilberforce area, Ontario
1—Silver Crater (Basin) mica and betafite mine, 2—Fission (Richardson) uranium mine, 3—Cardiff uranium and fluorite mine, 4—Essonville amphibole occurrence.

Large crystals have grown along most of the contacts, with hornblende crystals up to 11 feet (3.3 m) long, biotite plates up to 4 feet (1.2 m) in diameter, and albite crystals up to 1 foot (30 cm) in diameter. Within the calcite core, there are scattered euhedral crystals of green apatite up to 2 feet (60 cm) long, books of biotite up to 6 inches (15 cm) in diameter, cubo-octahedra of betafite up to 3 inches (7 cm) in diameter, and prismatic zircons up to 1 inch (2.5 cm) long, small flakes of molybdenite and irregular masses of pyrrhotite. Minor amounts of granular white to pink fluorite occur locally.

Bleached halos surround betafite crystals in the buff to pinkish calcite. Crystals of hornblende along the walls, as well as crystals of apatite and betafite within the core, contain isolated, rounded, relict pellets of calcite, indicating that the crystals are later than and have replaced the core-material.

In its composition, structure, texture, and relations with the host-rocks, this deposit falls within the general range of the vein-dykes, and its genesis is probably similar to that of the others in the region.

Selected references: 14, 26, 76.

Fission (Richardson) Uranium Mine (Locality 2, Figure 16)

Uraninite was discovered in calcite-fluorite vein-dykes on this property in 1922. At intervals between 1929 and 1955, several extensive exploration and development programs were undertaken, first for radium, then for uranium and fluorite, but there has been no production. In the 1930's radon-bearing mine-water was marketed in Toronto for its supposed curative powers.

The property is in Cardiff Township, Ontario, about 2 miles (3 km) northeast of Wilberforce. The main showing is reached via a gravelled road which leads eastward from the Wilberforce-Harcourt highway at the east end of Lower Cardiff Lake. Uphill, about ¼ mile (400 m) to the east, there is an access-road which leads southwestward for 0.8 mile (1300 m), terminating at the mine.

Surface workings include numerous, widely scattered trenches and strippings (Fig. 17). About 15,000 feet (4600) m) of diamond-drilling was done. Underground workings consist of an adit driven about 500 feet (150 m) southeastward into a hillside and terminated by a shaft. Several drifts and raises were driven from the adit-crosscut, and

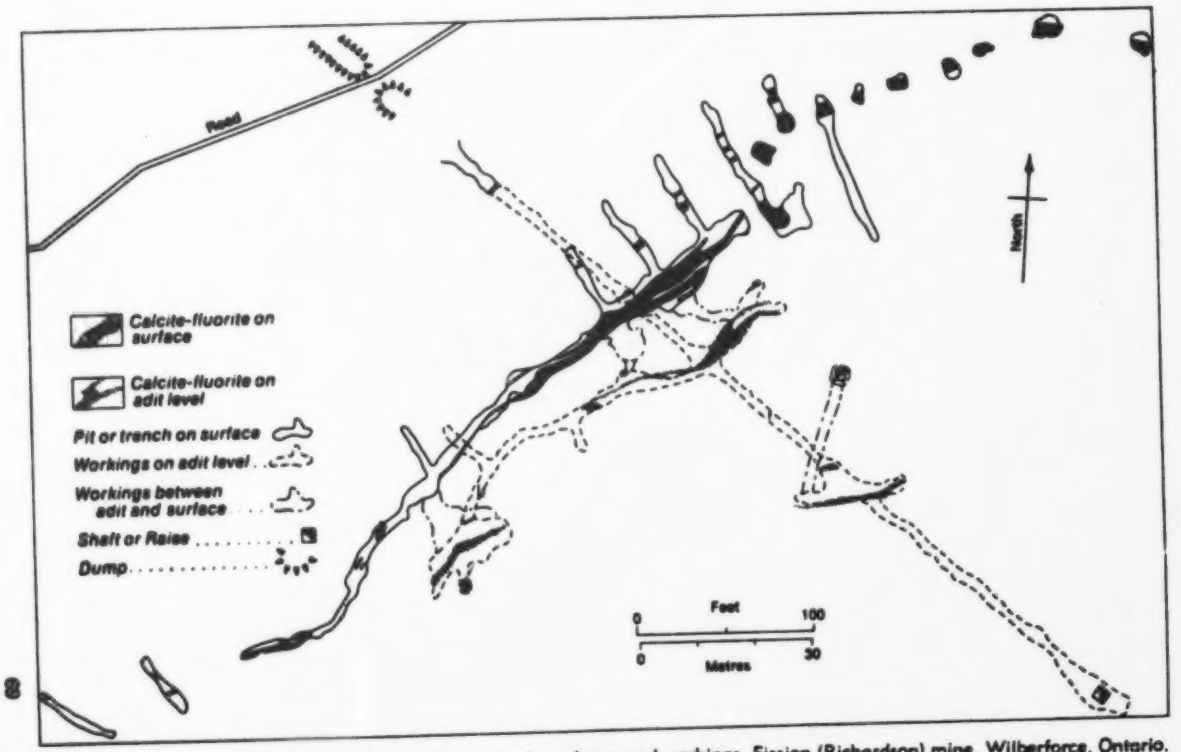


Fig. 17. Calcite-fluorite vein-dykes, surface and underground workings, Fission (Richardson) mine, Wilberforce, Ontario.

some stoping was done to provide feed for a pilot-mill. Because of the chimney-like configuration of shaft and adit, thick ice begins to accumulate early in the winter and may remain through August.

The country-rocks are variably syenitized biotite-gneisses and amphibolites, underlain by a thick series of partially silicated marbles. The altered gneisses are of many types, including peristerite-rich gneiss and corundum-bearing alkaline gneiss. The main deposit consists of a series of closely spaced, subparallel vein-dykes which strike northeastward and dip southeastward. This *en echelon* series of vein-dykes has been traced for more than 700 feet (210 m) along strike. Most of the vein-dykes are more or less conformable with the structures of the enclosing gneisses, but some transect these structures. The bodies are extremely irregular in shape, thickness, and extent. Bifurcation, coalescence, and lensing-out are common. Some of the individual vein-dykes exceed 300 feet (100 m) in length, with maximum thicknesses of more than 10 feet (3 m).

Although vein-dykes are its most prominent features, the deposit is actually more complex, and there is almost continuous gradation from host-rocks to vein-dykes. Locally, the well-foliated, medium-grained syenitized gneisses have been recrystallized to patches of coarsely crystalline feldspar and hornblende, with lesser biotite and magnetite, and minor titanite and zircon. These pegmatite-like bodies may range up to several feet (1 m) in diameter. Next in the sequence are pegmatitic patches which contain small cores of calcite and/or fluorite. The other minerals show well-formed crystal faces where they penetrate the core-materials. Last in this sequence are the vein-dykes, in which the core-zone constitutes a substantial proportion of the whole mass. These bodies are generally more or less tabular, with crystals projecting inward from the walls. Some of the crystals are partially cavernous and enclose semi-isolated masses of the core-materials. Others may be more nearly euhedral, but contain completely isolated, rounded pellets of the core-minerals. Within the core, some minerals, particularly apatite, have developed as completely isolated, euhedral crystals and these, too, may enclose relict pellets of the core-minerals — calcite, fluorite, or mixtures of both.

The composition and structure of these vein-dykes indicate origin by hydrothermal 'fluxing' and recrystallization of wall rocks along bedding planes, joints, and other fractures. The abrupt termination of the vein-dyke, which is

exposed at the eastern end of the main stripping, strongly favours such an origin — the hanging-wall curving around around to become the footwall.

The principal minerals of the deposit are microcline, antiperthite, oligoclase (including peristerite), hornblende, calcite, fluorite, apatite, magnetite and biotite (lepidomelane). Present in minor amounts are uraninite, titanite, zircon, allanite, pyrite, pyrrhotite, chalcopyrite, molybdenite, and quartz. Except for the calcite and fluorite, most of the minerals occur as rough-to-well-formed crystals. Some of the crystals are quite large — hornblende to about 6 feet (2 m) long, apatite to 2 feet (0.6 m) long, and uraninite masses to 5 pounds (2 kg).

Uraninite occurs as cubic crystals (some with octahedral modification) and also as irregular masses. It is very erratic in distribution and can be found in various associations, including the pegmatite-like patches of recrystallized gneiss, syenitized wall-rocks adjacent to the veins, the crystal linings along vein-walls, and isolated within the vein-cores.

The calcite and fluorite, where unaffected by shearing, are coarsely granular. Most of the fluorite is the deep purple variety, antozonite. It is strongly thermoluminescent and triboluminescent, and smells of fluorine and ozone when crushed or abraded, all of which reflect radiation damage. The depth of colour of the fluorite is an indicator of the proximity of uraninite. The antozonite, on exposure to daylight for some time, will fade to become nearly colourless. Blocks on the dump which retain deep colour on their exposed surfaces contain crystals of uraninite which afford sufficient radiation to overcome the bleaching effects of the daylight.

Many parts of the vein-dykes have been sheared, with development of augen and mylonite structures and very complex flowage patterns.

Calcite has been leached from the upper portions of some of the vein-dykes, so that the crystal-lined walls are well-exposed in the strippings. Although weathered calcite, fluorite, and apatite are common, colourful alteration-products of uraninite are very rare. Thin, hematite-stained coronas surround many of the uraninite crystals.

Selected references: 14, 26, 62, 66, 76, 78.

Cardiff Uranium and Fluorite Mine (Locality 3, Figure 16)

Uranium and thorium minerals occur in numerous calcite-fluorite vein-dykes on this property. Between 1943 and 1955, several exploration and development programs were undertaken for uranium and fluorite, but there has been no production.

The property, which is quite extensive, is in Cardiff Township, Ontario. The occurrence on which most work has been done in 3 miles (4.8 km) south-southeast of Wilberforce. It is reached by a gravelled road which leads off the Wilberforce-Tory Hill highway at the north end of Wilbermere Lake. About 1 mile (1.6 km) northeastward along this road (just beyond the bridge across the Irondale River), an access-road leads southward about ¼ mile (400 m) to the mine.

Much trenching, pitting, and stripping has been done throughout the property. However, surface work on the major deposit has been quite limited; a few trenches, pits and strippings, some now covered by later installations and dumps. Surface exploration was followed by extensive diamond-drilling, then underground development; two adits, an inclined shaft, and workings on the 125-foot (38 m) and 250-foot (76 m) levels. The underground workings have been sealed-off and are inacessible, but there is a large stock-pile dump of material from these workings.

The country-rocks here are nearly on strike with those of the Fission mine, which is about 2.5 miles (4 km) to the northeast. On the Cardiff property, however, the major deposit is at the contact with the underlying marble, rather than some distance above it. The country-rocks are variably syenitized calcareous gneisses and amphibolites, immediately overlying an extensive series of partially silicated marbles. These rocks strike nearly north and dip 40° to 60° eastward. Most of the occurrences throughout the Cardiff property show the same range of mineral assemblages and structures as those on the Fission property, from pegmatite-like patches recrystallized from parent gneisses, through similar masses but with small cores of calcite and fluorite, to tabular calcite-fluorite vein-dykes. In most of these occurrences, well-formed crystals line the walls of the pods and veins. However, in some of the veins which constitute the major deposit, particularly the one which is now exposed in the surface-stripping, crystal linings are not well developed.

The main Cardiff deposit, like that of the Fission mine, consists of a series of closely-spaced, sub-parallel vein-dykes which are, individually, up to 4 feet (1.2 m) in maximum thickness and traceable for several hundred feet (100 m). These vein-dykes are more or less conformable with the bedding and foliation of the enclosing gneisses and marble, but also show pinching and swelling, bifurcation, cross-cutting, and lensing-out.

The composition and texture of the vein materials of the main Cardiff deposit differ from those elsewhere on this property and at the Fission mine. The iron-content of the vein minerals is low, the mica is a light-brown phlogopite; hornblende and magnetite are absent, but there is some diopsidic pyroxene; and scapolite is present rather than feldspars. The compositional difference of this series of vein-dykes is related to the principal country-rocks — iron-poor, partially silicated marbles — thereby accounting for the relatively low content of silicate vein-minerals, and for the iron deficiency in those which are present.

Calcite, fluorite, phlogopite and apatite are the major constituents; with lesser titanite, scapolite, and pyroxene; and minor uraninite. All but the calcite and fluorite occur as whole or fragmented portions of well-formed crystals up to a few inches (10 cm) in length. The uraninite occurs as cubes up to 1 inch (2.5 cm) in diameter. All of the crystals are suspended in a finely granular, greatly sheared groundmass of calcite and fluorite.

The absence of crystal linings from some of the vein walls, together with the strongly sheared appearance of the vein fillings, indicate that the vein materials, possibly with some crystal-fragments torn from the original walls, may have been squeezed into their present position by flowage in a solid state, in response to regional stresses at relatively low temperatures. Faulting, under the same conditions, could have carried unrecrystallized wall-rocks into juxtaposition with vein-cores, as in the hanging-wall of the vein exposed in the stripping.

A variety of spencite, intermediate between the type spencite and tritomite, was discovered in a calcite-fluorite vein-dyke exposed on surface, about 350 feet (100 m) north-northeast of the shaft. The spencite occurred as brownish, rounded aggregates associated with allanite, augite, oligoclase, microcline-perthite, and quartz.

Selected reference: 26.

Essonville Amphibole Occurrence (Locality 4, Figure 16)

Amphibole, as euhedral crystals up to 8 inches (20 cm) in length, occurs in a carbonate mass in Grenville gneiss near Essonville, Cardiff Township, Ontario. The occurrence crops out on the 'old' Essonville road 2 miles (3 km) west of its junction with the Wilberforce-Tory Hill highway, and has been well exposed in a pit adjacent to the road. The amphibole is dark-brown to black with a brilliant lustre, and is associated with prismatic phlogopite in a matrix of white calcite. Doubly terminated crystals are common and many are twinned.

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